CAUSES FOR POOR QUALITY AND DELAY IN ALUMINUM WORKS OF PUBLIC BUILDINGS UNDER THE MINISTRY OF URBAN DEVELOPMENT & HOUSING, AND FEDERAL GOVERNMENT BUILDINGS CONSTRUCTION PROJECT OFFICE

By

MULUALEM MERID BELAY

A Thesis Submitted to

The Department of Architecture and Civil Engineering for the Partial Fulfillment of the Requirement for the Degree of Masters of Science in Construction Technology and Management

ADDIS ABABA SCIENCE AND TECHNOLOGY UNIVERSITY

JUNE, 2018

DECLARATION

I hereby declare that this thesis entitled **"Causes for poor quality and delay in aluminum works of public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction project Office found in Addis Ababa."** was composed by myself, with the guidance of my advisor, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted, in whole or in part, for any other degree or processional qualification.

Name of candidate: ______________________

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CERTIFICATE

This is to certify that the thesis prepared by **Ms. Mulalem Merid Belay** entitled "**Causes for Poor Quality and Delay in Aluminum works of public buildings Under the Ministry of Urban & Housing, and Federal Government Buildings Construction Project Office found in Addis Ababa"** and submitted in fulfillment of the requirements for the Degree of Master of Science complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Aluminum is an important factor in the building and construction industry. Aluminum as a construction material also defines – how quickly, and how esthetically and attractively a building is constructed. However, in most aluminum construction works in our country, the problems of quality and delay are common phenomenon. The purpose of this study, was therefore, to identify the causes for the delay and low quality works in aluminum installation works on the selected 19 public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office in Addis Ababa, which are either completed or at the aluminum construction stage. The objective of the study was to assess the causes for the delay and poor quality services and their improvement techniques on the selected projects. The survey was carried on a sample of 56 respondents from three categories (consultants, contractors, and aluminum work subcontractors) at various levels. Quantitative data was collected by self-administered questioners. Comparative analysis and ranking of causes for the delay and poor quality services and suggested improvement methods was done using their Relative Importance Indices (RII) from the Likert's Scale data. Interview and desk studies were also performed to collect more information and data. The research result indicated that, the problems occur due to the major causes like: inadequate work plan preparation at the initial stage, inadequate coordination of resources, lack of clearly defined responsibilities, lack of technological awareness, and inadequate design information from consultant. In line with identified of causes, the research also indicated that, effective and integrated work plan for site activities, assigning skilled workforce are identified as the major improvement techniques for the delay and poor quality works. Conclusion were made that causes for the delay and poor quality aluminum works are composite and combination of mitigation measures are necessary to reduce the problems. The study recommended a system undertaking to develop appropriate improvement techniques that are relevant to challenges experienced locally. Suggestion for further study was given to establish the reasons for the delay and poor quality works and also to replicate the study to establish whether the findings can be generalized for other projects.

Key words: Aluminum work construction, Quality management, Fabrication, Installation

ACKNOWLEDGEMENT

First, I would like to express my deepest appreciation to my respected advisor Dr. Eng. Wubishet Jekale, for his professional assistance and continuous encouragement while I was working on this research. I am very much grateful to all who have given me unreserved assistance in obtaining the information and data needed for this work. My special thanks goes to the professionals, consultants and construction firms for their willingness to provide me with all the necessary data and valuable information. I would like to extend my deepest gratitude to my family and friends for their unlimited support and appreciation also goes to my husband, Tefferi G.Meskel, without his sincere support and encouragement this would have not been possible.

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ABBEREVATION /ACRONYMS

CM	Construction Management
QC	Quality control
QA	Quality assurance
TQM	Total Quality Management
CPM	Critical Path Method
ITP	Inspection and Testing Plan
BPM	Building Project Management
KFS	Key Factors for Success
KPIs	Key Performance Indicators
PID	Project Initiation Document
WBS	Work Breakdown Structure
BPM	Building Project Management
RII	Relative Importance Index
BOQ	Bill of Quantity
CNC	Computer Numerical Control
PMBOK	Project management Body of Knowledge
DMAIC	Define, Measure, Analyze, Improve, and Control
DMADV	Define, Measure, Analyze, Improve, and Verify)
PDSA.	Plan-Do-Study-Act
MUHDFGBCPO	Ministry of Urban & Housing Development, and Federal Government Buildings Construction Project Office

CHAPTER I

1 INTRODUCTION

1.1 Background

In building construction, aluminum was initially used for decorative purposes. Today it is used in wall panels, roofing, partitions, windows, doors, awnings and canopies. All aluminum structures and sub-structures are growing in popularity. Durability and finish ability are the key benefits closely followed by extrudability complex architectural sections can be produced. Much construction equipment, e.g. scaffolding, staging and ladders also employ aluminum (Talat, 1999).

According to Talat (1999), Aluminum is the reason for the changing image of modern cities and towns: the clarity of lines, the high desire to grow skyward, the beauty, functionality and environmental compatibility of present-day requirements. 25% of all aluminum produced worldwide is so commonly used in modern construction, strength to weight plus durability are the main reasons for aluminum to be selected in the construction industry.

Moreover according to Talat (1999), Aluminum is a tool for unlimited creativity in the hands of the architect, making it possible to create structures that cannot be made from wood, plastic, or steel. The glass faces of office skyscrapers are supported by lightweight and sturdy Aluminum frames. Entertainment, trade and exhibition centers literally rest on Aluminum frameworks. Stadiums, pools and other sports facilities are also built using Aluminum structures.

The characteristics and properties of aluminum as a material have led to revolutionary and innovative changes in building techniques and architectural and engineering projects.

Aluminum is leading the way into the future of the construction industry. The minimum design service life of Aluminum structures is 80 years. Aluminum structures can be slightly prone to damage in fires, but the metal becomes even stronger at low temperatures. Lightness is perhaps the more important quality of Aluminum. Also it is simpler, faster and more convenient to work with lightweight structures. Thanks to its low specific weight, Aluminum plate constitutes half the weight of steel with the same stiffness. So, the weight of Aluminum structures is one half to two-thirds the weight of steel structures and up to one-seventh the weight of reinforced concrete structures with the same bearing capacity (Rusal, 2017).

Moreover, according to Rusal (2017), Aluminum as a construction material, also defines – how well, how quickly, and how esthetically attractively a building is constructed. In general, timely completion and high quality performances are becoming key factors in modern construction project's performance. However, many Aluminum construction projects fail in timely completing the installation work and also fail to deliver the Quality standards agreed upon. In our country also, it is seen that, the quality of the projects employing Aluminum installation works are poor and also the time they require to finish the work is very much elongated. Project performance problems like delay and poor quality services will occur due to many reasons in the Aluminum construction industry.

This research work therefore, aims to identify the major causes for the poor quality installation works and the reasons for the delay of aluminum construction works in 19 projects under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office which are located in Addis Ababa.

By using literature review, survey questionnaires, desk studies and interview, this study will analyze the responses about the causes for the delay and poor quality works and also the possible improvement techniques for the problems.

1.2 Statement of the Problem

Aluminum is the most widely specified metal in building construction, and is used in all sectors from commercial building to domestic applications and in recent decades has been combined successfully throughout the building industry. Most door-windows and curtain wall frames are made of aluminum, and indeed it is commonly combined with glass panels, as with aluminum partitions and structural glazing. The combination is popular in public buildings and high-tech buildings with a large glass façade. (Davis, 1998)

Timely completion and high quality services and products are becoming key factors in Aluminum work construction projects. However, our current practice in the Aluminum works construction sector do not demonstrate the quality and timeliness of the work. Where Quality address how well the work is performed and/or how accurate or how effective the final product is and Timelin**ess** addresses how quickly, when or by what date the work is produced.

As described in Asim (2013), quality in construction industry, as meeting the requirements of the designer, constructor and regulatory agencies as well as the owner. Quality in construction is the confirmation of properly developed requirements. For a construction project, quality begins with requirements carefully developed, reviewed for adherence to existing guidance, and ultimately reflected in criteria and design documents which accurately address these needs. Quality in construction projects is not only the quality of product and equipment used in the construction of a facility, but the total management approach which ensures that construction is performed according to plans and specifications on time within a defined budget, and a safe work environment.

Chung (1999) also indicates that the quality of construction work is perceptual; the framework of reference is commonly the appearance of the final product. 'How good is good enough?' is often a matter of personal judgment and consequently a subject of contention and often impossible to quantify since a lot of construction practices cannot be assessed in numerical terms. The need to be satisfied includes not only the client, but also the expectations of the community as a whole, into which the completion of the project will be integrated.

According to Fung (2006) delay is defined as the slowing down of work without stopping construction entirely and that can lead to time overrun either beyond the contract date or beyond the date that the parties have agreed upon for the delivery of the project. Delays and quality problems are inevitable; however, they can be avoided or minimized when their causes are effectively identified and analyzed.

For this reason, this researcher sought to identify and analyze the causes for the delay and poor quality products and services of Aluminum installation works in the selected buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office to address the problems and indicate some improvement techniques. The study incorporates professionals from the consultant (representing the client), contractors and Aluminum companies to supply and fix the necessary material.

1.3 Research Objectives

1.3.1 General Objective

The general objective of this research is to find out the major causes for the poor quality product and services and delayed performance in the Aluminum construction works of selected buildings under the Ministry of Urban Development & Housing, and Federal Buildings Construction Project Office in Addis Ababa.

1.3.2 Specific Objectives

The objective of this research can be broken down into the following specific objectives:

1. To identify the major causes affecting the quality of aluminum construction works in the selected public buildings.
2. To identify the major causes of delay in the Aluminum construction works of selected public buildings
3. To identify improvement mechanisms and rank them in accordance to their priority in minimizing the delay and poor quality services in the aluminum installation works.
4. To recommend proper recommendations from the conclusion.

1.4 Research Questions

In order to address the research specific objective the study will focus on the following research questions:

I. Why is that finishing of the aluminum works will not be completed in the desired time and the quality of services and products fail to meet the industry standard?

II. What are the improvement techniques for the delay and poor quality works in the aluminum construction works?

1.5 Scope of the Study

The research focuses on the problems of aluminum installation works in relation with the building construction activities (Curtain wall and door-windows) in terms of their work quality and delay.

The study involves consultants, project engineers from construction companies and skilled personnel's from Aluminum installation work companies selected to assess the undesirable effects of the outcome.

The research covers the issues of 19 public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office as a population. Causes for the problems will be identified. The major causes of failures not to meet the expected quality and timelines and the major improvement techniques for same will be analyzed and indicated. The result of the research will show the most significant cases for the problems in focus and the improvement techniques suggested.

1.6 Significance of the study

The study will be conducted with the purpose to fulfil the followings:

I. Finding the major causes of delay and poor quality services and products in the aluminum installation works and understanding of the major improvement techniques for the major causes.

II. The main findings, lessons and recommendations of the evaluation with the focus on the objectives, functions, institutional responsibilities and best practices can also be adopted by other Aluminum construction projects in Addis Ababa.

Therefore, in carrying out this research to indicate the methods of improving the problems of quality and delay in the aluminum installation works, stakeholders in general and contractors and clients in particular will be sole beneficiaries.

1.7 Structure of the Thesis

This research consists of five main chapters as followings:

- Chapter one: Introduction: this chapter shows the main objectives of research, statement of the problem, and justification of research
- Chapter two: Literature review: this chapter shows a historical review from previous studied to identify the main factors affecting the performance of Aluminum works construction projects
- Chapter three: Methodology: this chapter shows the main methodologies used in previous studies and the methodology used in this research in order to achieve the required objectives
- Chapter four: Results analysis: this chapter shows analysis, description and discussion of research results
- Chapter five: Conclusions and recommendations

CHAPTER II

2 LITERATURE REVIEW

2.1 General

In building construction aluminum was initially used for decorative purposes. Today it is used in wall panels, roofing, partitions, windows, doors, awnings and canopies. All aluminum structures and sub-structures are growing in popularity. Durability and finish ability are the key benefits closely followed by extrudability complex architectural sections can be produced. Much construction equipment, e.g. scaffolding, staging and ladders employ aluminum (Talat, 1999).

According to Talat (1999) the application of Aluminum in construction and architecture slowed in the 1940s, as the metal was predominantly used for producing planes. It even earned a second name, "winged metal." But as early as the middle of the twentieth century, Aluminum became more and more popular in the construction of high-rise buildings and bridges. Window frames, panels, domed roofs and other wide-span constructions and ornaments were increasingly made with Aluminum. Today, it is used for roofs, siding, translucent panes, window and doorframes, staircases, air conditioning systems, solar protection, heating systems, furniture and many other things.

According to Rusal (2017), aluminum in Construction is defined as a product with unique properties, making it a natural partner for the building industry. Aluminum is a light, but strong metal, which is not prone to corrosion, which is non-toxic and durable, recyclable, and which can be given virtually any desired shape. Light and at the same time strong, grid shell makes it possible to build not only large-area buildings, but also to give them unusual shapes. Both steel and Aluminum, making possible a structure that is two thirds lighter, are used as materials. In addition, the roofs and walls of such buildings are made of

Aluminum plates, thus making it possible to reduce the load on the supporting construction considerably.

Aluminum structures can be slightly prone to damage in fires, but the metal becomes even stronger at low temperatures. As a result, Aluminum is today used in high-rise buildings and skyscrapers: just imagine how much they would weigh if steel were used, how deep the foundation would have to be and how much more expensive the whole building would be (Rusal, 2017).

Aluminum became more and more popular in the construction of high-rise buildings and bridges. Window frames, panels, domed roofs and other wide-span constructions and ornaments were increasingly made with Aluminum. Today, it is used for roofs, siding, translucent panes, window and door frames, staircases, air conditioning systems, solar protection, heating systems, furniture and many other things (Metalweb, 2013).

Aluminum has therefore become an essential product for the building industry and over the past 50 years its use in building applications has shown continuous and consistent growth. Aluminum is the reason for the changing image of modern cities and towns: the clarity of lines, the high desire to grow skyward, the beauty, functionality and environmental compatibility of present-day requirements (Metalweb, 2013).

According to Metalweb (2013) the glass faces of office skyscrapers are supported by lightweight and sturdy Aluminum frames. Entertainment, trade and exhibition centers literally rest on Aluminum frameworks. Stadiums, pools and other sports facilities are also built using Aluminum structures.

Most recently, Aluminum has played a significant role in the renovation of historic buildings. The characteristics and properties of Aluminum as a material have led to revolutionary and innovative changes in building techniques and architectural and engineering projects. Aluminum is leading the way into the future of the construction industry (Metalweb, 2013).

Moreover, according to Metalweb (2013) Aluminum extruded, rolled, and cast products are commonly used for window frames and other glazed structures ranging from shop fronts to large roof superstructures for shopping centers and stadiums; for roofing, sliding, and curtain walling, as well as for cast door handles, catches for windows, staircases, heating and air-conditioning systems.

2.2 Performance Problems in Aluminum Construction Projects

According to West (2017) the performance of the construction industry in general and the Aluminum work construction in particular is affected due to various reasons. Performance is related to many topics and factors such as time, cost, quality, client satisfaction; productivity and safety.

Aluminum Construction in Addis Ababa suffers from many problems and complex issues in performance. Major problems encountered are in:

- Quality of work
- Quality of Material
- Meeting Project Time
- Project Coordination

Although, there are many realistic reasons such as closures, amendment of drawings and amendment of the design, there are other different reasons affecting Aluminum construction projects performance in Addis Ababa. Such as: poor management and leadership; inappropriate participants; poor relations and coordination; absence of motivation, control, monitor or decision-making systems; inadequate infrastructure; cultural problems and economic conditions (Kebede, 2016).

According to Kebede (2016) in Addis Ababa, there are many Aluminum construction projects failed to demonstrate the required performance in terms of quality and project time. In addition, performance measurement systems are not effective or efficient to overcome these problems. Aluminum Construction projects performance problem appears in many aspects in Addis Ababa.

In construction industry where many parties need to cooperate and depend on each other a shortage of skilled employee will invariably become a barrier to overall quality. Any construction work should be undertaken by well-trained personnel to ensure the quality of work is up to a certain standard (J. von et al. 2012). The primary focus is not on whether an individual employee is doing a good or bad job. Instead, the focus is on whether the organization provides the processes and procedures that enable that employee to deliver high-quality results.

There are many constructed projects fail in Time and Quality performance, others fail in cost performance and others fail in other performance indicators.

In general, timely completion and high-quality performances are becoming key factors in modern construction projects performance. (Cynthia K. West, 2017)

Our current practice of the Aluminum works construction sector in Addis Ababa does not demonstrate accountability & dependability to take personal responsibility for the quality and timeliness of the work (Kebede, 2016).

2.3 Challenges in aluminum construction projects management

Muir (2005) shows the success of a project is judged by meeting the criteria of cost, time, safety, resource allocation, and quality as determined by the owner. The purpose of Project Management is to achieve goals and objectives through the planned expenditure of resources that meet the project's quality, cost, time, scope, and safety requirements.

Construction differs widely from manufacturing in that:

- the work is often seasonal;
- each project is unique;
- often involves remote sites with various access problems;
- the process is not as predictable;
- difficulty in applying automation;
- there is high potential for encountering unforeseen conditions;
- costs can vary according to conditions;
- difficult to manage and supply utilities and other resources;
- technical innovations are adopted slower;
- success is dependent upon the quality of its people;
- very custom-oriented;
- product can be of mind-boggling size, cost, and complexity;
- the work is not performed in controlled conditions, therefore highly impacted by weather and other environmental conditions

2.3.1 Time constraints

Muir (2005) indicates that time is money to owners, builders, and users of the constructed facility. From the owner's perspective there is lost revenue by not receiving return on investment, cash flow crunch, potential alienation and loss of clients/tenants, extended interest payments, and negative marketing impacts. From the users' perspective, there are financial implications similar to owners. Delays in upgrading facilities translate into operating at below optimum efficiency resulting in higher user cost. Delays in constructing or rehabilitating infrastructure negatively affect businesses and the public at-large.

Time implications from the constructor's perspective include liquidated damages (negative) and incentive/disincentive payments.

Delays result in extended overhead costs and put a crunch on critical cash flow. Extending project durations limits the constructor's bonding capacity and ability to bid more work (opportunity cost). Inefficient time management results in higher labor and equipment costs. A reputation for late completions is bad for business, especially in negotiated work. In today's intensely time driven business environment, superior planning, scheduling, and control are vital (Muir 2017).

Moreover, according to Muir (2017) CPM Critical Path Method schedules and linear schedules are valuable tools that provide several advantages in managing construction operations. Schedule preparation requires managers to think the project through prior starting the work and provides a structured approach to planning. Comprehensive schedules provide a means of communicating the work plan to others. Schedules must be an accurate portrayal of the work plan to realize the full value. A good, regularly updated schedule in the hands of a competent CM Construction Management is a powerful tool. Good schedules are critical to project success; however, they are only a tool. Schedules do not build things; people build things. Proactive rather than reactive control by the CM is a key to staying on schedule.

Events or conditions that cause delays and require appropriate action include weather, lower productivity than anticipated, delivery problems, resource constraints, changes in scope, and differing site conditions. The CM must manage or mitigate these situations in order to deliver a constructed project on time.

2.3.2 Challenges of quality control and quality assurance in aluminum works

Quality control (QC) is a procedure or set of procedures intended to ensure that a manufactured product or performed service adheres to a defined set of quality criteria or meets the requirements of the client or customer (Amani and March 2017).

The approach to quality has evolved from control (QC) to management (QM) through assurance (QA) and reached policies like Total Quality Management (TQM). In developed countries, where quality systems have been established long time ago, the principle has become to produce quality rather than to control it at the end.

The new approaches are not only beneficial to the customer but also to the manufacturer as cost of quality is optimized to minimize the total loss. The results are less cost per unit of better quality, more share in the market and increased profits (Davis, et al., 1989).

According to Amani and March (2017) Quality control represent increasingly important concerns for Aluminum works project management. Defects or failures in constructed Aluminum Window-Door and Curtain Walls can result in very large costs. Even with minor defects, re-construction may be required and facility operations impaired. Increased costs and delays are the result.

As with cost control, the most important decisions regarding the quality of a completed Aluminum works are made during the design and planning stages rather than during construction. It is during these preliminary stages that profile and accessory configurations, specifications and functional performance are decided. Quality control during construction consists largely of insuring conformance to this original design and planning decisions (Amani and March 2017).

Moreover, according to Amani and March (2017) Aluminum work construction quality control involves testing and inspection of materials and installations. The skillful supervision of Aluminum works installation and repair project requires vast knowledge: knowledge of profiles and accessories and systems, of installed Aluminum Window-Doors and Curtain walls and methods in different areas as well as of the usability of current Aluminum work practices and methods.

Gurus (2011) Quality Assurance is a part of Quality Management focused on the prevention of quality problems.

To establish and facilitate good QA, it is necessary to launch beneficial QM in the first place. QA should not underestimate within the organization and should be taken seriously as it provides measurement of performance (in service area), volumes (in product area) and efficiency in the customer support department/industry. ,Quality Assurance (QA) is a systematic way of ensuring that all the activities necessary to design, develop, and implement services. It is using more statistical techniques to be able to evaluate the quality of products/services against requirements and verify that the data quality objectives were met.

2.4 Project time management

The construction industry is one of the main sectors that provide important ingredient for the development of an economy.

However, many projects experience extensive delays and thereby exceed initial time and cost estimates. Construction delays are considered to be one of project success in term of time, cost, quality, and safety (Assaf and Al-Hejji 2006).

The construction industry has a very poor reputation for coping with delays. Delay analysis is either ignored or done subjectively by simply adding a contingency. As a result many major projects fail to meet schedule deadlines (Duran 2006).

Sadi A. Assaf (1995) available literature reviewed indicate categorization of the various factors in groups of up to eleven (11) categories of consultant-related, contractor - related, design-related, equipment-related, externality - related, labor-related, material-related, owner-related, project-related, engineer-related and human-behavior related among others.

This study however re-clustered these factors into four (3) broad categories of consultant-related, contractor-related, and Installers-related factors.

As reviewed by Kebede (2016) during the Aluminum Window-Door and Curtain Wall installation process, Time Management is a crucial element for the success of the project.

PMI (2013) indicates that, the Project Time Management can include the processes required to manage the timely completion of the project.

Project Time Management processes requires:

- Plan Schedule Management - The process of establishing the policies, procedures, and documentation for planning, developing, managing, executing, and controlling the project schedule.

- Define Activities - The process of identifying and documenting the specific actions to be performed to produce the project deliverables.
- Sequence Activities - The process of identifying and documenting relationships among the project activities.
- Estimate Activity resources - The process of estimating the type and quantities of material, human resources, equipment, or supplies required to perform each activity.
- Estimate Activity durations - The process of estimating the number of work periods needed to complete individual activities with estimated resources.
- Develop Schedule - The process of analyzing activity sequences, durations, resource requirements, and schedule constraints to create the project schedule model and
- Control Schedule - The process of monitoring the status of project activities to update project progress and manage changes to the schedule baseline to achieve the plan.

2.5 Project quality management

Project quality management is all of the processes and activities needed to determine and achieve project quality. At its most basic level, quality means meeting the needs of customers.

Quality Management is also one of the key factors to determine the success of any project including Aluminum Construction Company's project acceptance and their client satisfaction (PMBOK Guide 2017).

As indicated in PMBOK (2017) Project Quality Management includes the processes for incorporating the organization's quality policy regarding planning, managing, and controlling project and product quality requirements in order to meet stakeholders' objectives. Project Quality Management also supports continuous process improvement activities as undertaken on behalf of the performing organization.

Construction companies will also benefit from applying the Quality Management procedures as indicated in the PMBOK Guide. Which are:

- Plan Quality Management - The process of identifying quality requirements and/or standards for the project and its deliverables and documenting how the project will demonstrate compliance with quality requirements and/ or standards.
- Manage Quality - The process of translating the quality management plan into executable quality activities that incorporate the organization's quality policies into the project.
- Control Quality - The functions also represent users' expectations; therefore, contrasting

  (1) Identifying the causes of poor process or product quality and recommending and/or taking action to eliminate them; and

  (2) Validating that project deliverables and work meet the requirements specified by key stakeholders necessary for final acceptance.

Quality Management has slowly been adopted by Aluminum construction companies in Addis Ababa as an initiative to solve quality problems and to meet the needs of the final customer Million Kebede (2016). As described in PMBOK (2017) Quality Management Practices of construction companies to achieve this aim will require two specific objectives:

a. committed to Quality Management Planning in the delivery of Aluminum work construction projects;
b. determined to withstand the challenges encountered while implementing quality assurance during the execution of the Aluminum work projects

Figure.2.1. provides an overview of the Project Quality Management processes. The Project Quality as described in detail in the PMBOK® Guide, 2017 management processes are presented as discrete processes with defined interfaces while, in practice, they overlap and interact in ways that cannot be completely. In addition, these quality processes may differ within industries and companies.

Project Quality Management Overview

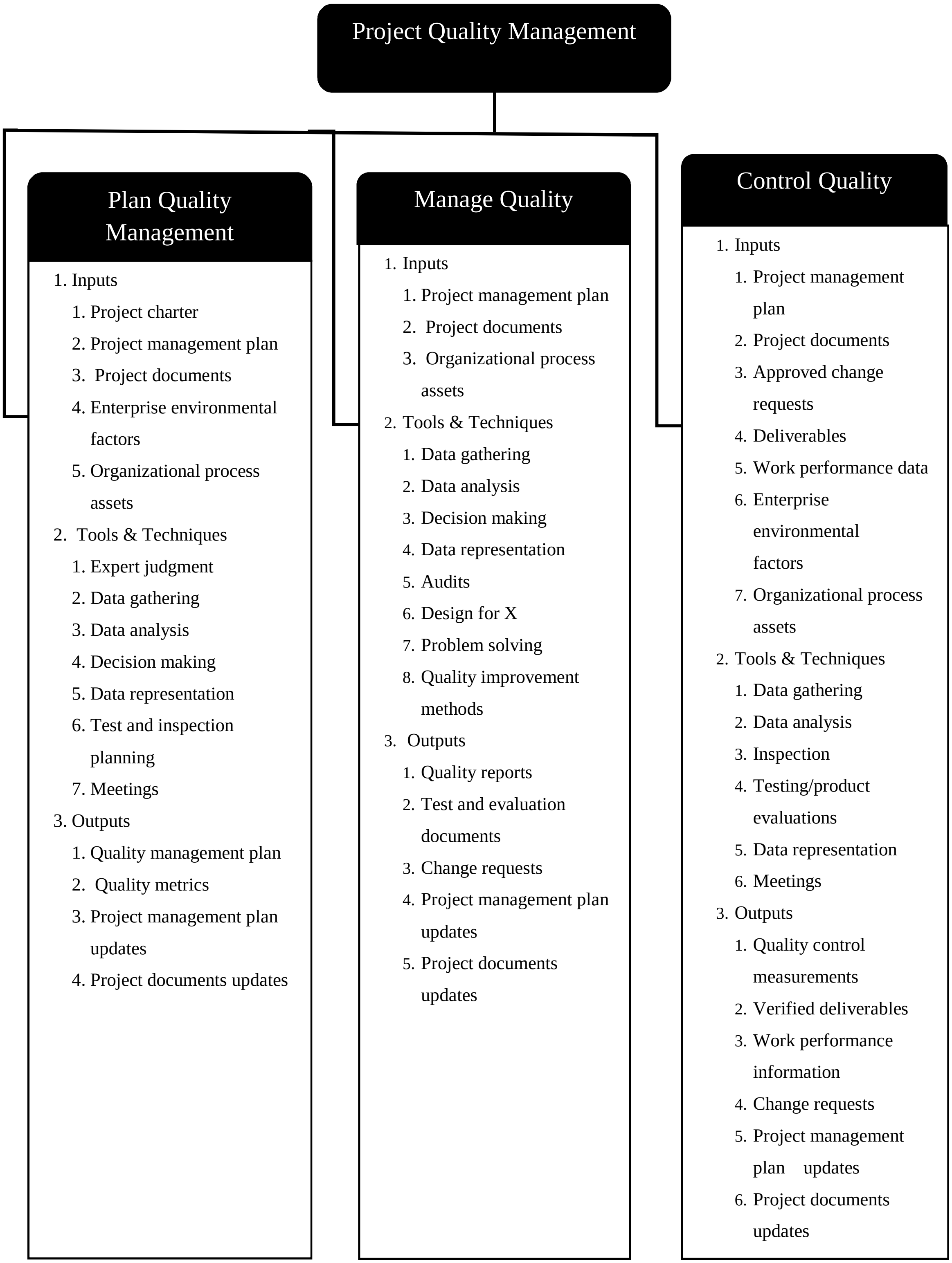

Figure 2.1. Project Quality Management Overview (Source: PMBOK Guide, 2017)

Figure. 2.2. Provides an overview of the major inputs and outputs of the Project Quality Management processes and the interrelations of these processes in the Project Quality Management Knowledge Area.

According to the PMBOK® Guide (2017) the Plan Quality Management process is concerned with the quality that the work needs to have. Manage Quality is concerned with managing the quality processes throughout the project.

During the Manage Quality process, quality requirements identified during the Plan Quality Management process are turned into test and evaluation instruments, which are then applied during the Control Quality process to verify these quality requirements are met by the project. Control Quality is concerned with comparing the work results with the quality requirements to ensure the result is acceptable. There are two outputs specific to the Project Quality Management Knowledge Area that are used by other Knowledge Areas: verified deliverables and quality reports.

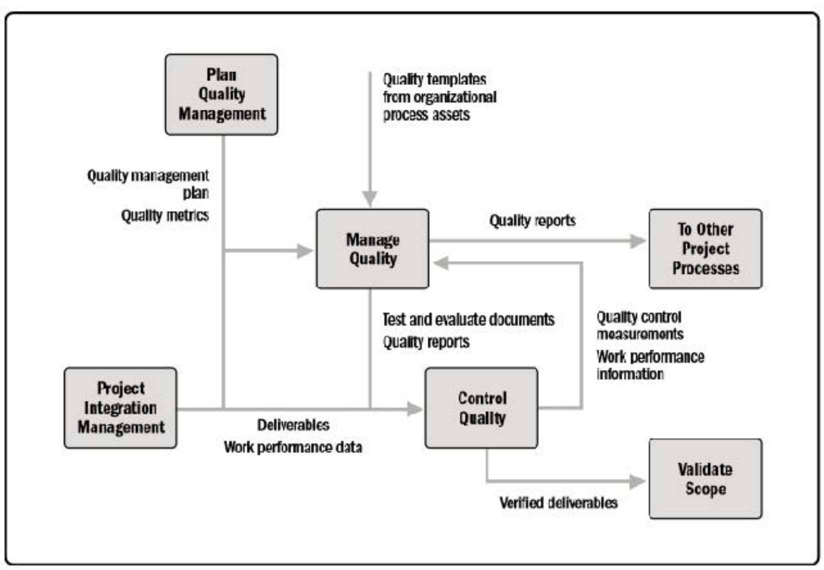

Figure 2.2. Project Quality Management Process Interrelations (Source: PMBOK Guide, 2017)

Moreover, according to the PMBOK® Guide (2017) there are five levels of increasingly effective quality management as follows:

- Usually, the most expensive approach is to let the customer find the defects. This approach can lead to warranty issues, recalls, loss of reputation, and rework costs.
- Detect and correct the defects before the deliverables are sent to the customer as part of the quality control process. The control quality process has related costs, which are mainly the appraisal costs and internal failure costs.
- Use quality assurance to examine and correct the process itself and not just special defects.
- Incorporate quality into the planning and designing of the project and product and
- Create a culture throughout the organization that is aware and committed to quality in processes and products

2.6 Trends and practices of quality management in aluminum works

According to Pyzdek (2013) modern quality management approaches seek to minimize variation and to deliver results that meet defined stakeholder requirements. Trends in the Aluminum Installation Project Quality Management include but are not limited to:

- Customer satisfaction: Understand, evaluate, define, and manage requirements so that customer expectations are met. This requires a combination of conformance to requirements (to ensure the project produces what it was created to produce) and fitness for use (the product or service needs to satisfy the real needs). In agile environments, stakeholder engagement with the team ensures customer satisfaction is maintained throughout the project.
- Continual improvement. The plan-do-check-act (PDCA) cycle is the basis for quality improvement. In addition, quality improvement initiatives such as total

quality management (TQM), Six Sigma, and Lean Six Sigma may improve both the quality of project management, as well as the quality of the end product, service, or result.

- Management responsibility. Success requires the participation of all members of the project team. Management retains, within its responsibility for quality, a related responsibility to provide suitable resources at adequate capacities.
- Mutually beneficial partnership with suppliers. An organization and its suppliers are interdependent. Relationships based on partnership and cooperation with the supplier are more beneficial to the organization and to the suppliers than traditional supplier management. The organization should prefer long-term relationships over short-term gains. A mutually beneficial relationship enhances the ability for both the organization and the suppliers to create value for each other, enhances the joint responses to customer needs and expectations, and optimizes costs and resources.

"Companies that adopted quality management practices experienced an overall improvement in corporate performance. In nearly all cases, companies that used total quality management practices achieved better employee relations, higher productivity, greater customer satisfaction, increased market share, and improved profitability" (Pyzdek, 2013).

A properly deployed Six Sigma program addresses the major issues encountered in TQM (Keller, 2011):

- Focus. TQM often sought widespread adoption of quality techniques across the organization. Six Sigma deployment revolves around projects concentrating on one or more key areas: cost, schedule, and quality. Projects are directly linked to the strategic goals of the organization and approved for deployment by high-ranking sponsors, as documented in a project charter (a contract between the sponsor and the project team).

- The scope of a project is typically set for completion in a three- to four-month time frame, delivering a minimal annualized return. Improvement is achieved one project at a time.
- Organizational support and infrastructure. TQM sought to diversify quality into the organization by training the masses, in the expectation they would use quality methods to make local process improvements. Middle management could easily thwart these efforts, usually on the sound premise that they interrupted operations. The Six Sigma deployment provides an infrastructure for success. As noted above, the deployment is led by the executive team, who use Six Sigma projects to further their strategic goals and objectives. Projects are actively championed by mid and upper level leaders in their functional areas to meet the challenges laid down by their divisional leaders (in terms of the strategic goals). Teams are led by Black Belts trained as full-time project leaders in the area of statistical analysis and problem solving, while process personnel are engaged as process experts (and trained in as Green Belts in the basic methods).
- Methodology. A standard methodology has been developed for Six Sigma projects: DMAIC, an abbreviation for Define, Measure, Analyze, Improve, and Control.
- When new products or services are designed, we can alternatively use the DMADV approach (replacing Improve with Design and Control with Verify), although the techniques are essentially the same. The importance of the methodology is in its structured approach, fundamentally based on Shewhart's Plan-Do-Study-Act (PDSA). This discipline ensures that Six Sigma projects are clearly defined and implemented; that organizational buy-in is built among the key stakeholder groups; that data-driven decision making is used to analyze and improve the process; and

that results are standardized into the daily operations, preventing only partial or short-lived project success. The objectives of each stage of DMAIC are summarized in Table 2.1.

- Training. A final key difference is the level and extent of training throughout the organization. A properly structured Deployment starts at the top, with training of key management as Six Sigma Champions. At the executive-level, they steer the program to achieve strategic objectives which summarized in Table.2.1.

Table 2.1. DMAIC/DMADV Stage Objective

DMAIC Stage	OBJECTIVE
Define	Project Definition: Define project's scope, goals, and objectives; its team members and sponsors; its schedule and deliverables.
	Top-level Process Definition: Define the stakeholders, inputs and outputs, and broad functions.
	Team Formation: Assemble highly capable team from the key stakeholder groups; Create common understanding of issues and benefits for project.
Measure	Process Definition: Define the process at a detailed level, including decision points and functions.
	Metric Definition: Define metric to reliably establish process estimates.
	Process Baseline: Use the defined metrics to establish the current state of the process, which should verify the assumptions of the Define stage. Determine whether the process is in statistical control.
	Measurement Systems Analysis: Quantify errors associated with the metric.
Analyze	Value Stream Analysis: Determine value-producing activities.
	Analyze sources of process variation.

	Determine process drivers.
Improve/Design	Propose one or more solutions to sponsor; Quantify benefits of each; Reach consensus on solution.
	Investigate and address failure modes for new process/design; Define new operating/design conditions.
	Implement and verify new process/design.
Control	Standardize new procedures/product design elements.
	Continually verify project deliverables.
	Document lessons learned.

(Source: Keller (2011))

Keller (2011) indicates that at operational levels, they allocate resources to project teams, providing the authority, resources, and the far-reaching appreciation of business needs necessary for project success. Once Champions have been trained, and project selection criteria has been established, Black Belts are trained just in time in the application of DMAIC, including change management skills, problem solving, statistical and lean principles, and methods.

Green Belts are selected from critical process areas, and trained to serve as process experts on specific process improvement projects. The ultimate goal is data-driven decision making at all levels of the organization, focused on benefits to their three stakeholder groups: customers, shareholders, and employees.

2.7 Quality and time management in the aluminum construction

As indicated by Brown & Adams (2000) there is a strong relation between project management and project performance. Management of quality and time in the construction sector (also in the Aluminum works) is considered as one of the most important factors affecting performance of works. Brown & Adams (2000) studied a new approach to the measurement of the effect of Building Project Management (BPM) on time, cost and quality outputs using 15 `cases' derived from UK data. The evaluation undertaken demonstrates that BPM as it is presently implemented in the UK fails to perform as expected in relation to the three predominant performance evaluation criteria; time, cost and quality.

Success of Aluminum work construction projects depends mainly on success of performance. Many previous researches had been studied performance of construction projects. Dissanayaka & Kumaraswamy (1999) remarked that, one of the principle reasons for the construction industry's poor performance has been attributed to the inappropriateness of the chosen procurement system. This is also directly applicable to Aluminum works construction projects.

Reichelt and Lyneis (1999) remarked three important structures underlying the dynamic of a project performance which are the work accomplishment structure, feedback effects on productivity and work quality and effects from upstream phases to downstream phases. The main performance criteria of construction projects as financial stability, progress of work, standard of quality, health and safety, resources, relationship with clients, relationship with consultants, management capabilities, claim and contractual disputes, relationship with subcontractors, reputation and amount of subcontracting.

Kumaraswamy (2002) stated that construction time is increasingly important because it often serves as a crucial benchmarking for assessing the performance of a project and the efficiency of the project organization.

Sai (2004) identified project performance categories such as people, cost, time, quality, safety and health, environment, client satisfaction, and communication.

It is obtained by Navon (2005) that a control system is an important element to identify factors affecting construction project effort. For each of the project goals, one or more Project Performance Indicators (PPI) is needed. Human factors played an important role in determining the performance of a project.

Dissanayaka & Kumaraswamy (1999) discussed that, a number of unexpected problems and changes from original design arise during the construction phase, leading to problems in cost and time performance. It is found that poor site management, unforeseen ground conditions and low speed of decision making involving all project teams are the three most significant factors causing delays and problems of time performance in local Aluminum works.

Dissanayaka & Kumaraswamy (1999) remarked that project complexity, client type, experience of team and communication are highly correlated with the time performance; whilst project complexity, client characteristics and contractor characteristics are highly correlated with the cost performance.

Reichelt and Lyneis (1999) have indicated that, project schedule and budget performance are controlled by the dynamic feedback process. Those processes include the rework cycle, feedback loops creating changes in productivity and quality, and effects between work phases.

2.7.1 Quality control in Door-Window and Curtain Wall installation

(Turner & Muller, 2005) state as, a project is an endeavor in which human, material and financial resources are organized in a novel way, to undertake a unique scope of work, of given specifications, within the constraints of cost and time, so as to achieve beneficial change defined by quantitative and qualitative objectives. The success or the failure of the Aluminum work project is broadly assessed in three dimensions:

1. Cost – refers to any or part of the project‘s materials, supplies or external contracts.

2. Time – refers to any part of the project schedule, including the duration of individual tasks, milestones and deadlines.

3. Product performance – refers to the specifications, quality, scope or standards that part or the entire project is planned to achieve.

However, the project cannot be called successful or failed on the basis of these three parameters if viewed from the eyes of all the stakeholders involved in it. The same outcome of a project may mean different things to different people. One of the studies identified two criteria namely project management criteria and product success criteria, for defining project success. It is noted that project management success covers meeting time, cost and quality objectives, while product success deals with the ability of the project ‘s final product to meet the project ‘s owner ‘s strategic organizational objectives, satisfaction of users ‘needs and satisfaction of stakeholders ‘needs where they relate to the product (Turner & Muller, 2005).

According to BCA (2017) good design is an integral and essential part of Aluminum construction. Good design facilitates the Aluminum construction work to be carried out optimally within time and cost constraints as per the defined quality standard.

The best design will fail if not properly implemented. Experienced project managers, foremen, factory personnel, glaziers, ironworkers, crane operators and similar professionals are needed for a successful project, regardless of the type of curtain wall and installation method. Even with highly qualified contractors and sub- contractors, factory and field quality assurance and quality control are often not sufficiently planned or implemented. Refer the following major tasks to be done for quality control ((BCA), 2017).

2.7.2 Quality control in aluminum works construction

Kebede (2016) states that all projects should ensure the quality of all equipment, materials, structures, components and systems utilized in the construction, manufacturing and operation of all types of industrial facilities are up to date and certified, Comply with all relevant quality standards and regulations , Verify materials, parts and final products through independent checks, audits, inspections and witnessing, quality assurance and quality control (QA/QC) both off-site at manufacturers' facilities and on-site during the construction process.

According to Kebede (2016) all projects should have the following compliance in Addis Ababa Building inspection and certification like:

- Commissioning
- Conformity certification
- Construction supervision and technical control during construction
- Design verification of the construction plans
- Energy certification
- Health, safety and environment management
- Inspection of existing buildings
- Maintenance management
- Quality assurance and quality control inspections

Kebede (2016) described that, quality control in aluminum window installation works to be properly performed, the followings procedures must be done:

- Inspection and Testing Plan (ITP)
    - Before starting Fabrication and Installation, Inspection and Testing Plan should be established to keep proper quality of the works in accordance with the specification and standards.
    - ITP shall be submitted to the Project Engineer for approval.
- Sampling and Testing
    - Before starting Fabrication and Installation, Sampling and Testing shall be carried out on profiles and accessories by supervisors.
- Fabrication and Installation Inspection
    - Before deliver the materials to the site, fabrication inspection shall be conducted and after finished installation, installation inspection shall be conduct with witnessed by the Engineer.

2.7.3 Quality control works for aluminum curtain wall

Kebede (2016) also described that, quality control in aluminum curtain wall installation works to be properly performed, the followings procedures must be done:

- Organize a qualified team
    - Project executives should review the credentials of the people who will perform the work, including those constructing the modules in the factory and those erecting the wall at the site. Experience shows that the factory and field foreman are some of the most critical members of the contractor's workforce, if not the single most critical members.

- The speed of curtain wall erection makes prompt, sound decision-making by the contractors' and architect's field teams crucial to the performance of the building.

- Avoid Careless erection techniques
  - To take care during erection of the curtain wall is the most obvious caution. It is also one of the rules most often broken.

    There is an investigation of curtain walls with damaged stone, glass, aluminum, metal panels, gaskets and other materials caused by reckless transportation and placement of framing and panels during erection. Curtain-wall modules are often large, heavy and awkward and require careful planning and implementation of protective crating, handling, transportation and erection. It is critical to have experienced curtain wall installers perform the installation, not just members of the "right trade," for example glaziers or iron workers. Require installers with at least five years' experience in successful curtain-wall installation to comprise the key or lead positions in the erection crew.

  - Attempts to make up lost time from construction delays can result in damage to curtain wall components as crew's rush to meet unrealistic production target.

- Misalignment
  - Misalignment of adjacent curtain wall elements can have serious consequences. Such misalignment is often due to errors in laying out the structural framing systems, but might also result from lack of coordination of building structure tolerances and curtain wall tolerances, or improper layout of imbeds to receive curtain wall anchors. In the case of coordinating construction tolerances, if the construction tolerance for the structural frame

is +/- 1 inch over the height of the building and the tolerance for the curtain wall is +/- 1⁄4 inch over that same height, it is the curtain wall that will need to be adjusted to conform to the looser tolerance of the structural framing.

➢ Proper alignment requires field measurements by the curtain wall subcontractor, careful placement of curtain wall anchor assemblies, and coordination between the general contractor, curtain wall subcontractor and the ironworkers installing the structural steel. Layout of embeds in structural slabs, particularly post tensioned slabs, might require the development of special anchor conditions to avoid interference with the slab pull points and tendons. This coordination must take place in the early planning stages of construction and should not be left to the field technician. A laser level survey of the building structure before the start of curtain wall erection will help to determine what alignment problems are likely to occur and might help the design team to develop corrective action before the curtain wall is set on the building. Similarly, a level survey of the curtain wall components during erection can help to ensure proper alignment, though this is not standard practice.

- Performance testing

➢ Curtain wall mock-ups are critical for identifying systemic problems related to both design and construction. These tests help focus everyone's attention on the weak points of the system. A pre-construction mock-up in a testing facility, followed by a field mock-up during the early stages of construction, often help to identify fit-up and erection problems, as well as other unforeseen problems.

- Inspection and testing plan shall be developed before any production starts with defined time schedule.
- Fabrication and inspection checklist shall be prepared before production starts. Sampling and testing procedure and checklist shall be prepared before any sampling and testing work starts.

2.8 Aluminum installation works project management

According to Brown and Adams (2000) an evaluation framework to measure the efficiency of building project management (BPM) by using conventional economic analysis tools such as time, cost and quality.

Wegelius-Lehtonen (2001) Stated that, performance measurement systems are imminent in the construction firms. Effective and efficient management of contractors' organizational performance requires commitment to effective performance measurement in order to evaluate, control, and improve performance today and in the future.

Navon (2005) defined performance measurement as a comparison between the desired and the actual performances. For example, when a deviation is detected, the construction management analyzes the reasons for it. The reasons for deviation can be schematically divided into two groups: (a) unrealistic target setting (i.e., planning) or (b) causes originating from the actual construction (in many cases the causes for deviation originate from both sources). Navon (2005), stated that performance measurement is needed not only to control current projects but also to update the historic database. Such updates enable better planning of future projects in terms of costs, schedules, labor allocation, etc.

Pheng & Chuan (2006) Stated that the measurement of project performance can no longer be restricted to the traditional criteria, which consist of time, cost and quality. There are other measurement criteria such as project management and products.

Iyera & Jhab (2005) stated that measuring the performance of any construction project is a very complex process because modern construction projects are generally multidisciplinary in nature and they involve participation of designers, contractors, subcontractors, specialists, construction managers, and consultants. With the increasing size of the project, number of participants in the project also increases. The objectives or goals of all participants need not be same even in a given project. Hence to measure performance of a project without specifying the participant and without specifying the criteria for judging the performance holds no meaning.

2.8.1 Performance management for aluminum works

Performance measurements of Aluminum works must be relevant to both the fabricating and installation area. The measurements must drive and improve the design, procurement, material handling, production, and installation processes and relate directly to the successful accomplishment of projects (Kebede, 2016).

According to Marosszeky (1999) the choice of performance measurements to be used depends on the areas selected for improvement and this should relate back to the Key Factors for Success (KFS) established as part of the fabricating, and installation works strategy. Key performance indicators (KPIs) include factors such as time, cost, quality, client satisfaction; client changes, business performance and safety in order to enable measurement of project and organizational performance throughout the construction industry.

Performance measurement and its indicators had been studied for several years. Performance measurement as an operational management accounting including financial and non-financial performance indicators. (Marosszeky, 1999)

Marosszeky (1999) also stated that performance measurement is a process of re-thinking and re-evaluation of business processes to achieve significant performance improvements of projects. According to previous studies, concepts and definitions, it can be said that the performance measurement is a process include factors as Key Performance Indicators (KPIs) such as time, cost, quality, client satisfaction; productivity and safety in order to enable measurement of current organizational project performance and to achieve significant performance improvements of future projects.

Kerzner (2011) indicates although most companies use metrics and perform measurement, they seem to have a poor understanding of what constitutes a KPI for projects and how they should be used.

MacMillan (2015) shows the road to effective performance management is not always an easy one, but progressing towards a long-term vision by making manageable changes, step-by-step, will bring about significant results. The points below act as a reminder of some of the key elements of a successful process.

- Communicate and understand purpose and value of process
- Set goals effectively
- Begin with performance planning
- Ensure an ongoing process
- Gather information from a number of sources
- Document, document, document
- Adequately prepare and train managers

- Deliver objective reviews that summarize an ongoing process
- Link performance management with other talent management processes
- Evaluate the process and make it easy, efficient and effective to ensure participation
- Consider the benefits of automation to save money and resources and optimize the performance management process.

2.9 Key Performance Indicators for Aluminum Installation Work

Defining the correct metrics or key performance indicators in the Aluminum construction works is a joint venture of the installer company/project manager, client, and stakeholders, and is a necessity in order to get stakeholder agreement. According to Kerzner (2011) one of the keys to a successful project is the effective and timely management of information. This includes the KPIs. KPIs give us information to make informed decisions and reduce uncertainty.

KPIs are critical components of all earned value measurement systems. Terms such as cost variance, schedule variance, schedule performance index, cost performance index, and time/ cost at completion are actually KPIs if used correctly but not always referred to as such. The need for these KPIs is simple: What gets measured gets done! If the goal of a performance measurement system is to improve efficiency and effectiveness, then the KPI must reflect controllable factors. There is no point in measuring an activity if the users cannot change the outcome (Kerzner, 2011).

Marosszeky (1999) Stated that the purpose of KPI's as to enable a comparison between different projects and enterprises to identify the existence of particular patterns. Marosszeky (1999) Used different representation values to evaluate time and cost performance such as project characteristics, procurement system, project team performance, client representation's characteristics, contractor characteristics, design team characteristics, external condition. (Marosszeky, 1999) Also stated that the development and use of key performance indicators (KPI's) can help to identify dysfunctional in the procurement process.

2.9.1 Benchmarking and Performance of Aluminum Works Construction

Benchmarking is an integral part of process improvement that provides a mechanism for making comparisons of project and program performance internally and externally. Aluminum construction works to be successful, benchmarking should be implemented as a structured, systematic process based on an understanding of critical success factors (Kebede, 2016).

Benchmarking is comparing one's business processes and performance metrics to industry bests and best practices from other companies. Benchmarking can be applied during various phases of a project for different purposes. When applied early on, such as at project authorization, it can be used to identify characteristics that may be associated with potential future problems and to identify aspects of project management (e.g., risk management) that need special attention to ensure project success. When applied during project execution, it can serve as a management tool to guide project decisions. Post-project benchmarking is usually used to assess performance of a project delivery system and to establish benchmarks for future comparisons (National Academy of Sciences, 2005).

Bogan & English (1994) defined benchmarking as a "process which continuously measures the products, services and operational practices of a given organization to compare the organization's performance and operational practices with a selected sample group".

Benchmarking involves a comparative analysis between at least two parties in order to compare the current performance gap. Chan-Albert and Chan-Daniel (2004) defined benchmarking as "the search for the best practices that will lead to superior performance of an organization".

Augusto et al. (2008) stated that the effective performance cannot be achieved without challenges and obstacles. To meet these challenges and overcome these obstacles, an organization must have a clear understanding of its performance in relation to its competitors. To accomplish best performance Aluminum installation work, an installer organization must have an organizational benchmarking system which is occupied with analytical models designed to measure multifaceted performance characteristics and parameter.

GGF (2011) declares the best practice of Aluminum window installation as follows. Prior to the commencement of work, the sizes, type and condition of all windows and door sets should be checked both against the survey sizes and types and against the actual aperture sizes. At the request of the installer, prior to the commencement of the work, the customer should be given adequate notice to remove any fixtures that may otherwise be damaged during the installation. The installer is responsible for both internal and external protection of the property during the installation work.

Renganathan & Srinivasan (2010) declares the best practice of Aluminum window installation as follows:

- Aluminum profile shall be as per the sectional drawings provided or as specified in the items. Each member of the window shall be well defined for its size, shape, weight per meter, profile and finish surface.

- Fabricator shall get fabrication or working drawings before starting the work. The drawing shall be done using dedicated design and optimizing software, high technology manufacturing machines and skilled workforce so that the quality of the products and services and the project time is properly planned and controlled for best performances.
- Aluminum profile sections shall be defined for manufactures like, ALCO, GULF, Arconic, Sapa, Constellium, Indal, and Hindalco or equivalent.
- High technology manufacturing machines and skilled workforce using well improve the quality of the products and services and the project time.
- Aluminum sections to be used for fabrication shall be well defined for anodizing (Matt finish or Glossy finish), natural or color anodizing, section with powder coating in different color etc. Aluminum Windows shall be specified for panel material like Glass / Laminated boards / Box type Aluminum lamination etc.
- Only approved hardware fixtures and accessories shall be used as per specification and tender items.
- Finished opening sizes should match perfectly with prefabricated Window sizes. To ensure about the exact dimensions, mockup sample or templates (either from wood material or M.S. material) shall be used.
- In case, dimensions don't match with the material supplied, openings shall be rectified.
- Arrangement for all approved hardware fittings and accessories as per the drawing shall be ensured before fixing of the material.
- Glazing shall be fixed to the extruded Aluminum profile sections by means of extruded Aluminum beading. Glass panes shall be provided with rubber lining before fixing.

- Aluminum frames shall be fixed to the masonry by means of Aluminum lugs fixed to the frame (by counter sunk galvanized machine screws) and the hole/pocket will be grouted with M-15 grade concrete. Any steel material coming in contact with Aluminum shall be galvanized.
- All Aluminum Window profiles should have protective film or coating. This film or coating can be removed only at the time of handing over (on completion of all civil works including painting)

2.10 Aluminum Installation and Construction Project Management

The construction industry in general and the Aluminum installation works in particular relies on the collective experience and initiative of the workers and staff to transfer expertise and experience from one project to the next. It has been quite common for construction methods to evolve through a large amount of interaction and deliberation of the workers and staff subsequent to the award of the contract and right down to the time of construction. The quality control method statements and work procedures must be based on the input from the workers, particularly the experiences of trades and technical staff. The system must not be rigid, thus, it must leave the door open for continuous improvements to the planned methods, right up to and during the construction time (Jaafari, 1996).

Koutsogiannis (2017) explains the primary functions of construction project management and describes that construction management is typically extended to a plethora of different functions. The most important of them could be summarized to the following:

i. Specification of the project goals and the plans including drawing of scope, scheduling, budgeting, deciding upon achievement requisites and choosing project participants.
ii. Boost of the resource effectiveness through the acquisition of workforce and of the necessary equipment.
iii. Conduction of numerous operations through legitimate coordination and management of contracting, planning, estimating, design, and construction during the whole procedure.
iv. Efficient development of solid communication between the agents for resolving any conflicts that may arise.

In general, according to Koutsogiannis (2017) every project has a standard life cycle, regardless of its special characteristics and the structure of Project and the Management Processes could be outlined to four basic stages:

i. *Project Initiation* - During the first phase, the objective and the feasibility of the project are determined. This is a crucial stage of the whole process, since it can indicate whether this project is a good opportunity or not. If necessary, a feasibility study is conducted and based on its results a recommended solution/plan is issued.

   Once everything is decided, a project initiation document (PID) is created. The project initiation document provides the groundwork for the construction plan and is one of the most vital artifacts in project management.

ii. *Planning Phase* - The project planning stage is where the team singles out all the work to be done. It's an ongoing activity almost to the end of the project. The main priority, during the planning phase, is to plan time, costs and resources for the project. Based on those requirements the team is developing the strategy that has to be followed.

This is also known as scope management. Another important document that has to be prepared is a work breakdown structure (WBS), a checklist that divides all the necessary work into smaller more functional categories.

Reliable scheduling can also help to eliminate many risks that may come up during a construction project. The main goal of scheduling is to improve the allocation of materials and resources within a project. In that way, any potential delays can be avoided and a better communication between all the different parties could be ensured. There is a certain number of different scheduling techniques that a project manager could select of which Line of balance scheduling technique is an extremely useful method for repeated tasks. It can provide remarkable help in meeting deadlines and assigning resources effectively.

iii. *Execution Phase* - In the execution phase, the construction project management plan is put to work. As a rule, this phase is divided in two main processes: the executing and the monitoring and controlling. The project team makes sure that the required tasks are being performed. At the same time, progress is monitored and changes are being made accordingly.

iv. *Closing Phase (Closure)* - The final stage of the project represents its official completion. The project manager is evaluating what went well and refers to any potential failures. In the end, the team conducts a project report, calculates the final budget and offer information about any tasks that remain unfinished. The project report in combination with the analysis of the potential failures will be valuable feedback for future construction projects.

2.11 Local Practice of Aluminum Window-Door Fabrication and Installation

Kebede (2016) when working at the local construction company Teklebrehan Ambaye Construction Company, has prepared a game changer operational manual with the objectives to increase customer satisfaction, service and products quality, operational speed or reduce process time, cost reduction, enhance innovation, productivity, etc. According to Kebede (2016) the basic requirements for Aluminum construction companies as described in the Game changer procedure for Aluminum works Management are:

2.11.1 Fundamental requirements for Aluminum works

- Material and skilled workforce requirement
- Qualification of installers and manufacturers (Workshop Technicians)
- Measurement requirement on site

2.11.2 Local Practices on Aluminum Works Installation Process

The work process mainly involves: Approval of material and shop drawing as per the specification, Delivery, storage and handling, Fabrication (QC during production), Preparation works, Installation works, Glazing Sealant Application, Water-tightness test, Protection and cleaning, Quality control, Safety control, Monitoring & Evaluation Services are main work process.

2.12 Challenges related to Design of Curtain Wall

Kazmierczak (2008) provides basic information on curtain wall components, design, testing and construction. Introduction of the curtain walls was caused by the following needs:

- Smaller wall footprint → resulting in extra floor area available for occupants
- Parallel scheduling → resulting in faster erection
- Lighter structure → resulting in material and transportation savings
- Structural flexibility → resulting in easier seismic engineering
- Improved light access → resulting in a more flexible and economical architectural layout
- Structural independency → resulting in a more flexible architectural layout.

According to Kazmierczak (2008) fundamental Classification: Curtain walls, in the structural sense of the expression, come in a wide variety of materials and systems, escaping attempts of rigid classification. The type of wall is not always obvious to an observer. In strictest architectural parlance, a “curtain wall” is any non-load-bearing exterior wall that hangs (like a curtain) from the face of floor slabs, regardless of construction or cladding material. However, in common usage, the term curtain wall usually refers to aluminum framed systems carrying glass, panels, louvers, or occasionally, granite or marble.

Moreover, according to Kazmierczak (2008) the name “curtain wall” became commercially associated with a light secondary rigid framing system filled or covered with a lightweight cladding. Classification of this narrow group of curtain walls may follow many different characteristics:

- By place of assembly: stick systems, unitized, semi, etc.
- By function: fire rated, acoustic, blast resistant, etc.
- By mullion materials: wood, steel, aluminum, composite, glass, etc.
- By mullion type: tubular, truss, cable, structural glass, etc.
- By glass type: reflective, low-iron, anti-reflective, etc.

- By glass attachment: captured, structural, semi, planar, etc.
- By glazing access (for replacement): internal, external.
- By configuration: single, double skin, freeform.
- By heat transfer: warm, cold, thermally improved, thermally broken (or the material group per DIN 4108 standard).

The types of curtain wall systems in use today include Stick, Unitized, Column Cover & Spandrel, and Point-Loaded Structural Glazing. These classifications are based on the type of frames used to construct the curtain wall and where the system is assembled (Memari, 2013).

Memari (2013) mentioned that the two types of curtain wall are characterized by the manner in which they are produced: stick built and unitized.

- Stick systems - The vast majority of curtain walls are installed long pieces (referred to as sticks) between floors vertically and between vertical members horizontally. Framing members may be fabricated in a shop, but all installation and glazing is typically performed at the jobsite. Stick-built walls have higher site labor costs (site labor is generally costlier than shop labor), because most of the assembly and glazing takes place there, which also results in a longer schedule to enclose a building. However, the biggest drawback of stick-built systems is that installation (assembly and glazing) is done outdoors in full exposure to the weather. Sealants are an important component of curtain wall that prevent air and water infiltration.

According to (Memari, 2013) sealant durability depends on good adhesion to the joint surfaces they are sealing, and good adhesion requires clean and dry joint surfaces, which can be difficult to obtain in variable weather conditions outdoors. Regulated temperature and humidity, such as exists in an indoor environment, and are conducive to more reliable sealant application.

Stick-built walls are assembled on the building and consist of tubular aluminum profiles. Mullions are assembled first, then horizontals are fastened to the mullions with clips or spigots. Glazing begins once enough framing has been installed and progresses up the tower to complete building enclosure (Memari, 2013).

- Unitized systems - Unitized façade systems belong to the family of curtain walls but follow a slightly different strategy. In order to be able to manufacture the façade in the workshop, it is built in components.
- Therefore, a sectional interface needs to be introduced that allows the connection of the components on-site. The benefit is obvious: The complex production process can be executed in the dry and clean factory. The quality can be controlled. Assembly times at the construction site are reduced and therewith the dependence of wind and weather. On the other hand, a higher logistical effort is required, and adaptations at the construction site are virtually impossible. Transportation is more elaborate. The unitized approach results in a different constructional strategy: Instead of a mullion, a more complex frame system is needed. The size of the combined frames is usually bigger than that of a single mullion, and more material is needed to stiffen the units during transport. But still, especially for large and complex projects unitized systems can result in overall cost savings (Klein, 2013).

Unitized curtain walls entail factory fabrication and assembly of panels and may include factory glazing. These completed units are hung on the building structure to form the building enclosure. Unitized curtain wall has the advantages of: speed; lower field installation costs; and quality control within an interior climate controlled environment. (Memari, 2013).

Morris (2013) defines curtain walls and their types that the time required to close in a building is greatly reduced with unitized systems because most of the production is done in the shop. Installation simply involves placing preassembled and pre-glazed frames on the building. Often unitized curtain wall installation follows immediately after erection of the structure. As a result, building close-in time is greatly reduced. Unitizing requires split members that interlock with the adjoining frame in a male-female interlocking method that incorporates gaskets for a joint that is both air and water tight.

2.13 Project Integration Management

Aluminum installation work, as an integral part of the construction process, all project management integration techniques are also applicable. Project Integration Management includes the processes and activities to identify, define, combine, unify, and coordinate the various processes and project management activities within the Project Management Process Groups (PMBOK, 2013)

In the project management context, integration includes characteristics of unification, consolidation, communication, and integrative actions that are crucial to controlled project execution through completion, successfully managing stakeholder expectations, and meeting requirements. Project Integration Management includes making choices about resource allocation, making trade-offs among competing objectives and alternatives, and managing the interdependencies among the project management Knowledge Areas. The project management processes are usually presented as discrete processes with defined interfaces while, in practice, they overlap and interact in ways that cannot be completely detailed (PMBOK guide, 2017).

According to the PMBOK (2013) overview of the Project Integration Management processes, are as follows:

- Develop Project charter - The process of developing a document that formally authorizes the existence of a project and provides the project manager with the authority to apply organizational resources to project activities.

- Develop Project Management Plan - The process of defining, preparing, and coordinating all subsidiary plans and integrating them into a comprehensive project management plan. The project's integrated baselines and subsidiary plans may be included within the project management plan.
- Direct and Manage Project Work - The process of leading and performing the work defined in the project management plan and implementing approved changes to achieve the project's objectives.
- Monitor and control Project Work - The process of tracking, reviewing, and reporting project progress against the performance objectives defined in the project management plan.
- Perform integrated change control - The process of reviewing all change requests; approving changes and managing changes to deliverables, organizational process assets, project documents, and the project management plan; and communicating their disposition.
- Close Project or Phase - The process of finalizing all activities across all of the Project Management Process Groups to formally complete the phase or project.

2.14 Testing mockups and field inspection requirements

According to Kazmierczak (2008) different types of testing can be implemented depending on the job specific and a function of the building-envelope complexity, project size, number of system types, and building usage. Sequencing of testing is primarily done in two phases:

- Prior to building construction by the testing of a mockup
- In-field testing at different stages during construction

As to Kazmierczak (2008) testing of the curtain wall system provides valuable information about potential problems or validation of expected performance. It can be a great learning tool, especially in the scenario where multiple systems types and materials interface within the building envelope. Because all subcontractors are responsible for their scope or material type, the challenge always occurs at interfaces and in the necessary coordination among different trades. Along with testing, field inspection of curtain wall installation is critical. Typical questions related to field inspection include the level of review required for a project, who will provide this review, how often will the review occur, and who has responsibility on the back end.

As indicated by (Mark Baker, 2009) Mockups are prototypes representing and replicating sections or portions of the curtain wall system or building envelope. They often encompass aluminum framing, glazing, natural stone panels, metal panels, or other perimeter materials as dictated by the project. The mockups can be constructed of different sizes and, if being tested in a laboratory, be limited to the laboratory test chamber's dimension or capability. Mockups comprise basically two types: visual and performance.

2.15 Design Responsibilities and Communication

According to Kazmierczak (2008) Majority of failures seen in the field could be easily prevented by an adequate design or a subsequent quality control. In some cases, there is an implied, misplaced expectation a contractor would conduct quality control of the design. Observing the design and construction process we could identify gaps in communication and misunderstood delegation of responsibilities as major culprits of failures of building enclosures. It's also observed, that in case of building envelope failures, the cost is typically paid by insurance companies, owners, and contractors, while control is mainly in hands of designers and manufacturers.

In the most typical scenario a curtain wall is delivered as one of a number of Design Build systems on a Design-Bid-Build façade. The process can be briefly characterized by two main stages:

First design stage: In the traditional design-bid-build mode, a curtain wall is first defined by an architect of record, who should provide oversight of work of the structural and mechanical engineers and other (acoustical, blast, lighting, fire, code) consultants. The secondary structure and structural connections between each façade system lie in a grey area between scopes of the architect and the structural engineer. The connections should be engineered by a structural engineer (responsive to both types and magnitude of loads and locations at which the proprietary façade systems would need support) and coordinated with functional façade control layers, to allow for proper transitions of thermal, waterproofing, air, vapor, and other control layers. This inter-systemic anchorage and transitions should be engineered with input from someone with a sufficient knowledge of the adjacent systems to allow for proper transitions of all façade control layers, in order to provide their continuity.

Delegated design stage: In the construction phase, the systems are delegated to respective Design-Build teams for engineering of their respective systems. In the ideal world, the engineering teams would receive both design data and performance requirements mentioned earlier to allow for proper engineering.

According to Kazmierczak (2008) It is observed that a significant gap between the users' expectations and actual performance of curtain walls, ranging from a simple glare discomfort to a major structural collapse. In the course of the design, forensic investigation, and consulting activities we can identify the reasons for poor performance is often a misunderstanding of fundamental principles of facade design and structural concept of curtain walls by construction parties, and gaps of oversight and coordination in the established project delivery routines.

The study of Kazmierczak (2008) verifies that, it would be logical to design building enclosures (not just curtain walls) to address their expectations. The external skin, freed from load-bearing function, acts purely as a building envelope, protecting the interiors from forces, such as:

- Earthquakes – controlled by e.g. ductility and Rain – controlled by e.g. waterproofing, seals, and screens
- Sun - controlled by e.g. shading and coating
- Heat Flow -- controlled by e.g. thermal insulation, low emissivity and absorptivity surfacing
- Light- controlled by e.g. shading and coating
- Wind - controlled by continuous path of a structural resistance
- Windborne Debris- controlled by opening protections
- Blast - controlled by a continuous path of a structural resistance
- Water Vapor - controlled by configuration of vapor retarding and permeable layers
- Air flow - controlled by air barriers
- Aggressive Airborne and Waterborne Chemicals - controlled e.g. by adequate coatings
- Wildlife – controlled by e.g. bird nets, termite barriers, baffles, etc.
- Dirt Accumulation – controlled e.g. by sloping configuration, hydrophilic surfaces.

- Snow - controlled e.g. by sloping, parapet, and ledge configuration, heat traces, etc.
- Flood - controlled by e.g. openings
- Hail - controlled by resistive layers
- movement joints
- Noise and vibrations- controlled by e.g. addition of mass, damping, skewing and distancing layers
- Maintenance Loads - controlled by means of access and continuous path of a structural resistance
- Fire – controlled by e.g. thermal resistive layers
- Smoke– controlled by e.g. smoke and air resistive layers
- Theft – controlled by e.g. organic glazing layers, shutters, steel plating, and openings hardware
- Normal Wear and Tear – requiring e.g. maintenance and inspection access.

Moreover, According to Kazmierczak (2008) the list of priorities will vary depending on project requirements. The façade functions should be considered in conjunction with each other because they overlap. The functions also represent users' expectations; therefore, contrasting them with the typical performance failures. Curtain walls are complex systems comprised of many separate components; however, their failures as whole units may be generally divided into the following categories:

- Design Errors and Omissions, e.g. improper choice of materials and systems.
- Materials without proven performance, e.g. insufficiently tested glass coating technologies.
- Deficient Shop Fabrication, e.g. failure to detect early and prevent by QA and QC.

- Deficient Field Installation,
- Improper or Deterred Maintenance, e.g. underfunded maintenance budget, improper of missing staff training, omission of commissioning design - “instruction manual,”
- Ordinary wear and tear, e.g. failure of “bottleneck” materials and solutions.

2.16 Water penetration as a major problem in Aluminum curtain wall

According to American Architectural Manufacturers Association (2005) a wall may be designed and constructed so that water can enter into the wall but is then drained safely to the outside. Water may penetrate a wall or component in one of six basic ways: Gravity, Wind pressure, Air borne, Kinetic energy, Surface tension, and Capillary action

Water penetration could also be caused by:

- Failure to seal openings that should be sealed and the incorrect fitting of gaskets leaves openings through which the wind can force water

- Failure to lap components such as flashings, wrongly fitted gaskets and poor sealant joints will all create openings that allow water to flow into the wall under gravity. If drainage paths are blocked water will pond and overflow (often into the wall) under the effect of gravity

- Incorrect installation can allow water to enter by any of these above mechanisms even if the wall is designed to prevent water penetration.

- Failure to install air seals correctly allows air to pass through the wall and this may carry water into the wall

Removal of drips and nibs from the underside of components can allow water to remain attached to the surfaces and run into the wall as a result of surface tension

2.17 Procurement Management

According to Bennett & Grice (1990) procurement process directly affects the quality and time of Aluminum projects. Since almost all Aluminum profiles are imported from suppliers abroad - their type, quality and other relevant characteristics shall be selected during preparation for ordering. Ordering the right profile requires knowledge of the material. To properly supply the required material for the Aluminum projects, inventory control system is also a very important factor. Monitoring the stock level, deciding the ordering period to shorten the lead time, inspecting quality of material when receiving, and material handling during storage and transporting are the necessary activities to deliver quality Aluminum installation works on time. The efficient procurement of a construction project through the choice of the most appropriate procurement strategy has long been recognized a major determinant of project success; and a failure to select an appropriate procurement approach as the primary cause of project dissatisfaction (Masterman, 2002).

The selection of a procurement method should be viewed as an iterative process whereby project objectives and constraints are constantly compared with possible procurement solutions. To assist with marrying project objectives and constraints with a procurement method, specific criteria can be used to assist clients with determining their priorities (NEDO, 1985):

1. Time: is early completion required?
2. Certainty of time: is certainty of project completion of time important?
3. Certainty of cost: is a firm price needed before any commitment to construction given?

4. Price competition: is the selection of consultants and contractors by price competition important?
5. Flexibility: are variations necessary after work has begun on-site?
6. Complexity: does the building need to be highly specialized, technologically advanced or highly serviced?
7. Quality: is high quality of the product, in terms of material and workmanship and design concept important?
8. Responsibility: is single point of responsibility the client's after the briefing stage or is direct responsibility to the client from the designers and cost consultants desired?
9. Risk: is the transfer of the risk from the client important?

PMBOK guide (2017) describes that, conduct Procurements is the process of obtaining seller responses, selecting a seller, and awarding a contract.

The key benefit of this process that indicates in Figure 3 provides alignment of internal and external stakeholder expectations through established agreements.

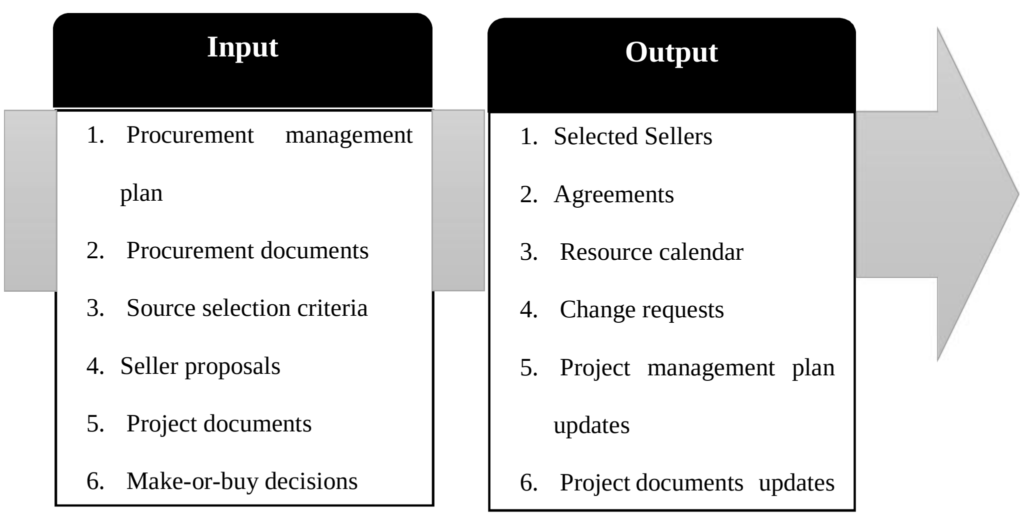

Figure 2.3.Conduct Procurements - Input and outputs

2.18 Quality and time management in the aluminum work installation

There is a strong relation between project management and project performance. Management in Aluminum work construction sector is considered as one of the most important factors affecting performance of works.

Brown & Adams (2000) studied a new approach to the measurement of the effect of Building Project Management (BPM) on time, cost and quality outputs using 15 `cases' derived from UK data. The evaluation undertaken demonstrates that BPM as it is presently implemented in the UK fails to perform as expected in relation to the three predominant performance evaluation criteria; time, cost and quality.

Success of Aluminum work construction projects depends mainly on success of performance. Many previous researches had been studied performance of construction projects. Kumaraswamy (2002) remarked that, one of the principle reasons for the construction industry's poor performance has been attributed to the inappropriateness of the chosen procurement system. This is also directly applicable to Aluminum works construction projects. Reichelt and Lyneis (1999) remarked three important structures underlying the dynamic of a project performance which are: the work accomplishment structure, feedback effects on productivity and work quality and effects from upstream phases to downstream phases. The main performance criteria of construction projects as financial stability, progress of work, standard of quality, health and safety, resources, relationship with clients, relationship with consultants, management capabilities, claim and contractual disputes, relationship with subcontractors, reputation and amount of subcontracting. Kumaraswamy (2002) stated that construction time is increasingly important because it often serves as a crucial benchmarking for assessing the performance of a project and the efficiency of the project organization.

Sai (2004) identified project performance categories such as people, cost, time, quality, safety and health, environment, client satisfaction, and communication.

It is indicated by Navon (2005) that a control system is an important element to identify factors affecting construction project effort. For each of the project goals, one or more Project Performance Indicators (PPI) is needed. Human factors played an important role in determining the performance of a project.

A number of unexpected problems and changes from original design arise during the construction phase, leading to problems in cost and time performance. It is found that poor site management, unforeseen ground conditions and low speed of decision making involving all project teams are the three most significant factors causing delays and problems of time performance in local Aluminum works (Dissanayaka & Kumaraswamy, 1999).

Kumaraswamy (2002) remarked that project complexity, client type, experience of team and communication are highly correlated with the time performance; whilst project complexity, client characteristics and contractor characteristics are highly correlated with the cost performance. Reichelt and Lyneis (1999) discussed that, project schedule and budget performance are controlled by the dynamic feedback process. Those processes include the rework cycle, feedback loops creating changes in productivity and quality, and effects between work phases.

2.19 Summary

According to previous studies, it can be said that the aluminum work requires skilled manpower. As indicated on chapter two the study focusses on construction of door and windows including curtain walls. From the literature review we can found that the following. So, the following are the causes that can be regarded as causes for delay and poor-quality work.

- Inadequate preparation at the beginning.
- Change in materials and scope of the project.
- Lack of support from the professional to laborers
- Insufficiency of technology
- Poor coordination between stakeholders.
- Outsourcing and lack of involvement of main contractor
- Damage material during transportation to site.
- Lack of information on the standards of aluminum works.
- Lack of proper alignment of the primary support for the glazing

CHAPTER III

3 MATERIALS AND METHODS

3.1 Introduction

This research is aimed to identify the main causes for the delay and poor quality services in the aluminum construction works of 19 public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO) found in Addis Ababa.

The thesis also attempts to develop some methods and tools to improve the problems which will eventually be useful to all the stakeholders for timely completion of Aluminum construction projects at an agreed and specified quality standard. This could be met by employing a diverse range of methods to collect applicable data. For this purpose it firstly attempts to critically review literatures to identify and describe generally accepted causes for the delay and causes for poor quality services. Secondly, field survey and desk studies have been conducted by using questionnaires and personal interviews to identify the main causes of delay and poor quality services and also to know the perceptions of three main participants; consultant, contractor and Aluminum work companies.

For the survey, a questionnaire was prepared in three section. The first section contains personal and organizational profile of respondents and the second section contains general questions that are relevant in forming the opinion on the problems of delay, poor quality services in 19 public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO).

The third section of the questionnaire is based on the possible factors causing delay and poor quality services in the Aluminum works construction projects and also the improvement techniques for both the delay and poor quality services.

This factors are grouped into four categories: I) causes related to delay; II) causes related to poor quality; III) Improvements to minimize delay; and IV) Improvements to minimize poor quality Aluminum works. The questionnaire was sent to the professionals of consultants, contractors and Aluminum work companies who are actively associated with the construction activities and possessing sufficient experience in the field of construction on a scale of 1 to 5 depending upon its effect, 5 being very high and 1 very least.

3.2 Research methodology

Johnson and Harris (2002) cited in (Derbe, 2016) describes that, research strategies can be broadly categorized as either quantitative or qualitative. Quantitative research is objective in nature. It usually requires respondents to record their attitudes, opinions, or beliefs on different-point scale measured with numbers (Krosnick & Presser, 2010). Three main approaches were suggested to collect the data: asking questions of respondents by means of questionnaires and interviews, undertaking experiments and performing extensive reviews of the relevant literature (Johnson & Harris, 2002). On the other hand, qualitative research is subjective in nature (Naoum, 2007). It relies on observing people in their own environment, communicating with them in their own language, and on their terms. Case studies are the major types of qualitative study. In addition, a research study using both qualitative and quantitative approaches can be called a “mixed-methods” approach (Creswell, 2009)

3.3 Selected research methods

This research employs mixed method where both qualitative and quantitative methods are used. The Quantitative aspects of this research is concerned with the identification of major causes for delay and poor quality works in Aluminum construction works of 19 public buildings under

Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO)using different-point scale measured with numbers.

Qualitative methods appear to be more appropriate for Interviews and desk studies for capturing relevant information in the study.

3.4 The research framework

The frame work of the research is shown in Finger.3.1. Below

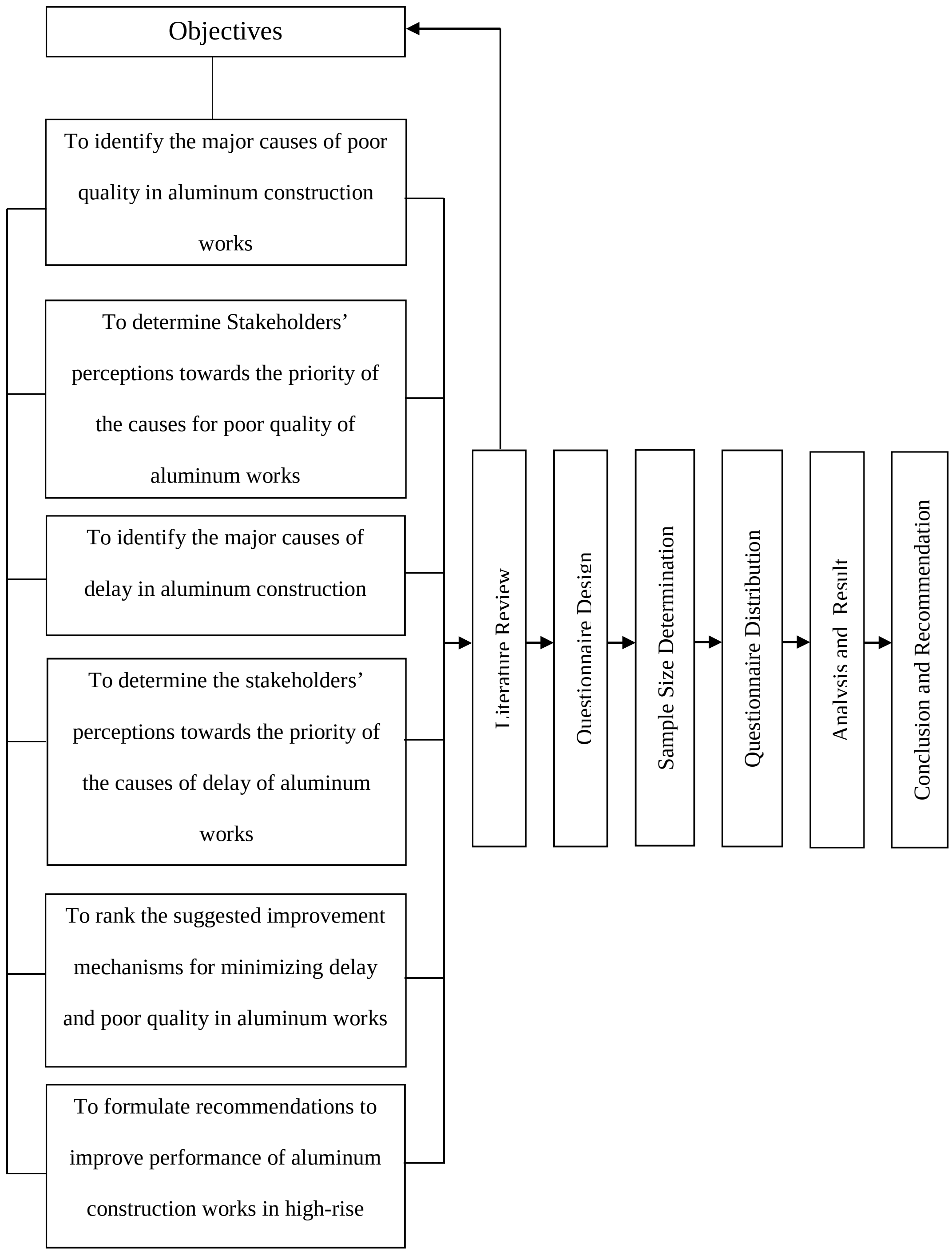

Figure 3.1. Summary of methodology used in this research

3.5 Population and Sampling

The population of the study as indicated is the public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO), which are completed or at the aluminum construction stages. The number of the buildings is 19 and all projects 100% are taken for the study.

The sampling method used in the study is stratified random sampling. Stratified sampling is used, if a population from which a sample is to be drawn does not constitute a homogeneous group, stratified sampling technique is generally applied in order to obtain a representative sample. Under stratified sampling the population is divided into several sub-populations that are individually more homogeneous than the total population (the different sub-populations are called 'strata') and then we select items from each stratum to constitute a sample. Since each stratum is more homogeneous than the total population, we are able to get more precise estimates for each stratum and by estimating more accurately each of the component parts, we get a better estimate of the whole (Kothari, 1990).

For this study it is used, because we have three stratum that are: the consultant's side, the building contractor's side, and the aluminum works contractor side, and the sampling is taken as below.

This study targeted to assess projects executed in Addis Ababa. The sample selection criterion is public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO), where their construction stage is reached at least to an Aluminum installation level.

The target groups in this study are contractor's professionals, consultant's professionals and aluminum works contractor professionals. Depending on the focus of the study there are 19 public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office where their level of construction is completed or at the aluminum construction stages. According to our study, there are 10 contractors for constructing all the 19 public buildings under MUDHFGBCPO.

Few, contractors have their own Aluminum construction crews to execute the installation works but in our case all contractors outsource the aluminum installation work to 5 aluminum work sub-contractors. There are also 6 consultants to represent the client and also responsible to design and supervise the respected projects. Kish (1965) showed that the sample size can be calculated as the following equation for 94% confidence level (Assaf et al 2001, Israel 2003, Moore et al, 2003):

n= n'/ [1+ (n'/N)]

Where:

- N = total number of population
- n = sample size from finite population
- n' = sample size from infinite population = S^2/V^2; where S^2 is the variance of the population elements and V is a standard error of sampling population. (Usually S = 0.5 and V = 0.06)

So, from 10 contractor's /organizations/ for 19 projects by taking 2 professionals from each project we will get a total of 38 respondents as a population:

- n= n'/ [1+(n'/N)]
- $n' = S^2/V^2 = (0.5)^2/ (0.06)^2 = 69.44$
- N = 38

- n= 69.44/ [1+(69.44 / 38)] = 24

This means that the questionnaire should be distributed to 24 contractor professionals in order to achieve 94% confidence level.

So, for aluminum workers for each contractor 1 fabricator and 1 installer totally 2 individuals from each contractor and 38 from all contractors:

- n= n'/ [1+(n'/N)]
- n'= $S^2/V^2 = (0.5)^2/(0.06)^2$ = 69.44
- N = 38
- n= 69.44/ [1+(69.44 / 38)] = 24

This means that the questionnaire should be distributed to 24 aluminum work professionals in order to achieve 94% confidence level.

For consultants, the number is determined from 6 consultants engaged in these 19 projects 1 designer each and 2 assistant site engineers from active sites are taken, totally 8 professionals taken and all are used as a sample. Because, it is not required to determine sample size using previous Kish equation and it can be selected from all of consultant's professionals.

According to previous results of sample sizes, 56 questionnaires were distributed as follows: 24 to contractor professionals, 8 to consultants and 24 to aluminum construction workers. 40 questionnaires were received (71%) as follows: 17 (30%) from contractor professionals, 5 (9%) from consultants and 18 (32%) from aluminum construction workers as respondents.

These percentages are shown in Figure.3.2.

Figure 3.2.Percentages of received questionnaires

3.6 Data Collection

The approach to data collection should be based primarily on the nature of the investigation and on the type of data and information that are required. The objective of this study is to identify the main causes for the delay and poor quality services and also to study the improvement techniques in the aluminum construction works of 19 public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO). This could be met by employing a diverse range of methods to collect applicable data. This included interviews, and case studies. Data gathered during interview will be recorded. As for the questionnaire it will be distributed by hand to the identified respondents.

3.7 Data Measurement

In order to be able to select the appropriate method of analysis, the level of measurement must be understood.

For each type of measurement, there is/are an appropriate method/s that can be applied and not others. In this research, ordinal scales were used. Ordinal scale as shown in Table 3.1. Shows ranking or a rating data that normally uses integers in ascending or descending order. The numbers assigned to the important (1, 2, 3, 4, 5) do not indicate that the interval between scales are equal, nor do they indicate absolute quantities. They are merely numerical labels. Based on Likert's scale we have the following table 2. (Cheung et al, 2004; Iyer and Jha, 2005; Ugwu and Haupt, 2007):

Table 3.1.Ordinal scale used for data measurement

Item	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
Scale	5	4	3	2	1

The relative importance index method (RII) is used here to determine all respondent's idea or opinion of the relative importance of the causes of failures to be focused in time, quality performances and improvement methods to minimize delay and poor quality. The relative importance index is computed as (Cheung et al, 2004; Iyer and Jha, 2005; Ugwu and Haupt, 2007):

Ordinal scale data measurement

$$RII = \frac{\sum W}{A \times N}$$

Where:

- W is the weight given to each factor by the respondents and ranges from 1 to 5
- A = the highest weight = 5
- N = the total number of respondents
-

3.8 Data Analysis Methods

This research discusses the causes for poor quality and delay and improvement techniques of the problems in the aluminum installation works of 19 public buildings under the MUDHFGBCPO which are found in Addis Ababa. Including Interview Analysis and desk study the basic methodology which is considered to achieve the objectives of this research is as the following issues:

3.8.1 To identify the major causes of poor quality and delay

In identifying the major causes of poor quality and delay in aluminum construction works (Concerning objectives one and three) from the literature review, we found that eight groups of causes for the problems mentioned. All causes are included in the questioners and the groups are summarized.

3.8.2 Stakeholders' priority on causes of poor quality and delay

Concerning objectives two and four (To determine stakeholders' perceptions towards the priority of the causes for poor quality and delay of aluminum works), a structured questionnaire survey approach was considered.

In addition, interview and desk studies were also used to study the attitude of aluminum workers, consultants and contractors towards the causes.

The relative importance index (RII) method is also used here to determine all respondent's idea or opinion of the relative importance of the causes of failures to be focused in time and quality performances. The relative importance index is computed as (Cheung et al, 2004; Iyer and Jha, 2005; Ugwu and Haupt, 2007):

$$RII = \frac{\sum W}{A \times N}$$

Where:

- W is the weight given to each factor by the respondents and ranges from 1 to 5
- A = the highest weight = 5
- N = the total number of respondents

3.8.3 Ranking suggested improvement mechanisms

Concerning objective five, to rank the suggested improvement mechanisms for minimizing delay and poor quality in aluminum works the relative importance index method (RII) is used to determine all respondent's idea on the relative importance of the improvements to minimize failures to be focused in time and quality performances. The relative importance index is computed as (Cheung et al, 2004; Iyer and Jha, 2005; Ugwu and Haupt, 2007):

$$RII = \frac{\sum W}{A \times N}$$

Where:

- W is the weight given to each factor by the respondents and ranges from 1 to 5

- A = the highest weight = 5
- N = the total number of respondents

3.8.4 **Form**ulate improvement techniques

Concerning objective six, to formulate recommendations on the improvement of aluminum construction works performance for all the buildings similar to that of the buildings under study, existing practices of aluminum installation works and the possible problems identified during the process were analyzed to determine the major causes for poor quality works and delay in order to formulate the recommendations.

3.9 Summary of the research process

The major characteristics of the research method is mixed. Mixed research is designed by incorporating both a qualitative and quantitative approaches.

Quantitative data is collected using survey questionnaire from the selected samples. The Likert's scale data will be analyzed using relative importance index (RII) method.

Literature review, questionnaire survey, and desk study with in-depth interview are also the methods used in this study. Literature review is used to identify major causes for the delay and poor quality services and also their improvement techniques in the aluminum construction works of the public buildings under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO). The questionnaire survey will be used to explore the opinions of the stakeholders to identify the major causes for the delay and quality problems. Finally, the recommendations and conclusions will be forwarded based on the literature review and findings of this research.

CHAPTER IV

4 RESULT AND DISCUSSION

4.1 General Information

This chapter presents the findings and results of the survey according to the objectives of the research. The main objective of the research being to identify the causes of delay and poor quality works in the aluminum installation works and also to indicate the improvement methods to minimize the delay and poor quality aluminum works focusing only on 19 buildings constructed under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO). Accordingly, interpretation and discussions will be presented on the basis of the findings and limitations observed. The complete survey questions are provided in the Appendix section A.

4.2 Sample Projects

Table 4.1 below shows the list of projects under Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO) and their correspondent consultant, contractor and Aluminum work subcontractor.

Table 4.1.List of Selected Projects under Study

No.	Project Name	Contractor Name	Consultant Name	Sub-contractor (Aluminum works) Name
1	Ministry of Health G+6	Samuel S/Mariam BC	MH Engineering PLC	B&C Aluminum PLC
2	Ministry of Agriculture G + 6	Prefabricated building parts production enterprise (and Giga Construction PLC)	MH Engineering PLC	B&C Aluminum PLC
4	Revenue and Customs Authority G+10	Zamra Construction	MH Engineering PLC	B&C Aluminum PLC
5	Ministry of Foreign affairs Conference hall building Conference hall	Rama Construction	Mulugeta Asfaw Architects and Engineers	G- Tech
6	Central Statistics Agency Office Building G+ 6	Giga Construction PLC	MH Engineering PLC	B&C Aluminum PLC
7	Ethiopian Press Agency G+ 6	Flintstone Engineering	MH Engineering PLC	B&C Aluminum PLC
8	Federal Prison Administration Office Building G+6	Flintstone Engineering	ETG Consulting Architects and Engineers	B&C Aluminum PLC
9	Ethiopian Road Authority Office Building G + 6	Samuel S/Mariam BC	MH Engineering PLC	B&C Aluminum PLC
10	Ministry of Industry Office Building G + 6	AMB Construction	ETG Consulting Architects and Engineers	AMB Aluminum PLC+E10:E11
11	Federal Main Auditor Bureau Office Building G+ 6	Radar Construction	ETG Consulting Architects and Engineers	B&C Aluminum PLC
12	Ministry of Public Service (Ethiopian Broadcasting Authority) Office Building G + 6	Samuel S/Mariam BC	ETG Consulting Architects and Engineers	B&C Aluminum PLC

No.	Project Name	Contractor Name	Consultant Name	Sub-contractor (Aluminum works) Name
13	Urban Integrated Land Information Development Agency 2B + G + 12	Teklebirhan Ambaye Construction	Defense Construction Enterprise	Yutaf Aluminum plc
14	Information Network Security Agency phase I 2B + G + 10	Defense Construction Enterprise	MH Engineering PLC	Zebian Aluminum and Glass industries LLC
15	Information Network Security Agency phase II	Defense Construction Enterprise	MH Engineering PLC	Zebian Aluminum and Glass industries LLC
16	Information Network Security Agency phase III	Defense Construction Enterprise	MH Engineering PLC	Zebian Aluminum and Glass industries LLC
17	Federal Supreme Court Judges apartment building 2B + G + 18	Teklebirhan Ambaye Construction	A F R I Consulting & Engineers PLC.	Yutaf Aluminum plc
18	Government Higher official and head of states Residence project B + G 2 (6 Building)	Teklebirhan Ambaye Construction	Defense Construction Enterprise	Yutaf Aluminum plc
19	Federal Government Communication Affairs Office Head Quarter Building Project 4B+16,2B+4 & G+3	Teklebirhan Ambaye Construction	Yohannes Abbay Consulting Architect & Engineers	Yutaf Aluminum plc

The experience and the professional workforce assigned on projects is listed below.

i. Company size (average number of employees on project sites):

Average number of employees in constructions’ organizations is 8 employees

Average number of employees in consultants' organizations is 2 employees

Average number of aluminum work employees in contractors' organizations is 8 employees

ii. Years of experience of the respondent:

Average number of experience years of the constructions’ respondents is 10 Years

Average number of experience years of the consultants' respondents is 12 Years

Average number of experience years of the aluminum work respondents is 10 Years

4.3 Verification for the existence of delay and poor quality

This study focuses on the causes for delay and poor quality on aluminum works. The problems were existing under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office (MUDHFGBCPO) as it is verified by respondents.

From the total of the respondents, for delay 95%of the respondents assure that delay is a common problem in aluminum works for public buildings under Ministry of urban and housing federal Government Building construction project office. The other 5% respondents have no idea whether there is a problem of delay or not.

Regarding quality problem only 3% of the respondents verify that there is no quality problem only their site regarding aluminum works. 90% of the respondents assure that there is a problem on quality of aluminum works. And the others 2% have no idea on existence of quality problem.

The following figures.4.1 and 4.2 shows the verification of existence of the problems.

Figure 4.1. Respondent’s opinion on the existence of delay

Figure 4.2.Respondent’s opinion on the existence of quality problem.

4.4 Survey Results and Analysis of Delay and Poor Quality

The analysis of the consecutive sections will indicate the ranks for the causes for the delay and poor quality services and products in aluminum installation works of selected buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office.

4.4.1 Analysis of Causes related to time delay

The results of this part of the study provides an indication of the ranks for the causes of the delays in aluminum installation works of 19 public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office using their relative importance indices from the Likert's scale data.

The Tables A, B, and C shown in appendix B indicates the causes of delay in view of contractors, Aluminum work subcontractors, and consultants respectively. The group analysis is shown below in Table. 4. 2

Table 4.2. Analysis on causes of delay in Aluminum works from the group view

No.	Causes related to delay	Aluminum Workers		Contractor		Consultant		Overall
		RII	Rank	RII	Ran k	RII	Rank	Rank
1	Delay in approval of material and shop drawing	0.878	1st	0.894	1st	0.88	1st	1
2	Shorter procurement lead time	0.878	1st	0.894	1st	0.88	1st	1
3	Lack of proper fabrication planning	0.878	1st	0.894	1st	0.88	1st	1
4	Dis organized delivery system	0.878	1st	0.894	1st	0.88	1st	1
5	Unauthorized installation and fabrication	0.878	1st	0.894	1st	0.88	1st	1
6	Glazing and sealing simply follows installation of frame	0.878	1st	all	1st	0.88	1st	1
7	Lack of technological awareness at the design stage	0.878	1st	0.894	1st	0.88	1st	1
8	Variation between BOQ and actual	0.878	1st	0.894	1st	0.88	1st	1
9	Lack of specific material	0.878	1st	0.894	1st	0.88	1st	1
10	Weak installation technicians assigning method	0.878	1st	0.894	1st	0.88	1st	1
11	Weak crew formation	0.878	1st	0.894	1st	0.88	1st	1
12	Disorganized fleet management	0.878	1st	0.894	1st	0.88	1st	1
13	Lack of details from drawings and descriptions	0.867	1st	0.894	1st	0.88	1st	2
14	Design change	0.867	1st	0.894	1st	0.88	1st	2
15	Weak project material handling	0.878	1st	0.882	1st	0.88	1st	2
16	Inadequate Resource availability	0.833	2nd	0.788	3rd	0.84	2nd	3
17	Lengthy process of importing	0.833	2nd	0.788	3rd	0.84	2nd	3
18	No enough skilled manpower available	0.833	2nd	0.788	3rd	0.84	2nd	3
19	Backward workshop machineries and tools	0.833	2nd	0.788	3rd	0.84	2nd	4
20	Lack of Involvement of Main Contractor	0.833	2nd	0.835	2nd	0.84	2nd	4
21	Weak communication	0.833	2nd	0.835	2nd	0.84	2nd	4
22	Lack of defined procedure	0.833	2nd	0.835	2nd	0.84	2nd	4
23	Lack of Commitment by Involved Parties	0.778	3rd	0.788	3rd	0.76	3rd	5
24	Site engineer, Forman, time keeper	0.778	3rd	0.788	3rd	0.76	3rd	5
25	Delayed response for reported problems	0.756	4th	0.741	4th	0.6	4th	6
26	Weak or no training program	0.756	4th	0.741	4th	0.6	4th	6
27	Un-even performance evaluation	0.756	4th	0.741	4th	0.6	4th	6
28	Rare site visiting and professional support	0.756	4th	0.741	4th	0.6	4th	6
29	Lack of clarity in responsibility Definition	0.722	5th	0.741	4th	0.6	4th	7

The result from the above table 4.2. indicates that, the rank of the causes for the problems affecting the timely completion of Aluminum installation work; Delay in approval of material and shop drawing, shorter procurement lead time, lack of proper fabrication planning, disorganized delivery system, unauthorized installation and fabrication, glazing and sealing simply follows installation of frame, lack of technological awareness at the design stage, variation between BOQ and actual, lack of specific material, weak installation technicians assigning method, weak crew formation and disorganized fleet management system are the primary causes for the delay in the aluminum construction works. Lack of details from drawings and descriptions, design change and weak project material handling are rated as the second major causes for the delay of aluminum construction works. Inadequate resource availability, lengthy process of importing and no enough skilled manpower available are the third ranked main causes for the delay in aluminum works. Backward workshop machineries and tools, lack of involvement of main contractors, weak communication and lack of defined procedure are ranked as the fourth main causes for delay in the aluminum construction work. Lack of commitment by involved parties (site engineer, Forman, time keeper) and delayed response for reported problems are ranked as fifth level causes for the delay. Delayed response for reported problems, weak or no training program, un-even performance evaluation and rare site visiting and professional support causes are ranked sixth place. Lack of clarity in responsibility definition is ranked seventh place from the problems listed as the cause for the delay of aluminum installation works in the projects under study.

4.4.2 Analysis of Causes related to poor quality

The results of this part of the study provides an indication of the ranks for the causes of the poor quality works in aluminum installation works of 19 public buildings under the

Ministry of Urban & Housing Federal Government construction project Office using their relative importance indices from the Likert's scale data.

The Tables D, E, and F shown in appendix B indicates the causes of delay in view of contractors, consultants, and Aluminum work subcontractors respectively. The group analysis is shown below in Table.4.3.

Table 4.3. Analysis on quality issues in Aluminum works on the group view

No	Causes related to poor quality	Aluminum works		Contractor		Consultant		Overall
		RII	Rank	RII	Rank	RII	Rank	Rank
1	Delay in approval of material and shop drawing	0.878	1st	0.894	1st	0.88	1st	1
2	Shorter procurement lead time	0.878	1st	0.894	1st	0.88	1st	1
3	Lack of proper fabrication planning	0.878	1st	0.894	1st	0.88	1st	1
4	Dis organized delivery system	0.878	1st	0.894	1st	0.88	1st	1
5	Unauthorized installation and fabrication	0.878	1st	0.894	1st	0.88	1st	1
6	Glazing and sealing simply follows installation of frame	0.878	1st	0.894	1st	0.88	1st	1
7	Lack of technological awareness at the design stage	0.878	1st	0.894	1st	0.88	1st	1
8	Variation between BOQ and actual	0.878	1st	0.894	1st	0.88	1st	1
9	Lack of specific material	0.878	1st	0.894	1st	0.88	1st	1
10	Weak installation technicians assigning method	0.878	1st	0.894	1st	0.88	1st	1
11	Weak crew formation	0.878	1st	0.894	1st	0.88	1st	1
12	Disorganized fleet management	0.878	1st	0.894	1st	0.88	1st	1
13	Lack of details from drawings and descriptions	0.867	1st	0.894	1st	0.88	1st	2
14	Design change	0.867	1st	0.894	1st	0.88	1st	2
15	Weak project material handling	0.878	1st	0.882	1st	0.88	1st	2
16	Inadequate Resource availability	0.833	2nd	0.788	3rd	0.84	2nd	3
17	Lengthy process of importing	0.833	2nd	0.788	3rd	0.84	2nd	3
18	No enough skilled manpower available	0.833	2nd	0.788	3rd	0.84	2nd	3
19	Backward workshop machineries and tools	0.833	2nd	0.788	3rd	0.84	2nd	4
20	Lack of Involvement of Main Contractor	0.833	2nd	0.835	2nd	0.84	2nd	4
21	Weak communication	0.833	2nd	0.835	2nd	0.84	2nd	4
22	Lack of defined procedure	0.833	2nd	0.835	2nd	0.84	2nd	4
23	Lack of Commitment by Involved Parties	0.778	3rd	0.788	3rd	0.76	3rd	5
24	Site engineer, Forman, time keeper	0.778	3rd	0.788	3rd	0.76	3rd	5
25	Delayed response for reported problems	0.756	4th	0.741	4th	0.6	4th	6
26	Weak or no training program	0.756	4th	0.741	4th	0.6	4th	6
27	Un-even performance evaluation	0.756	4th	0.741	4th	0.6	4th	6
28	Rare site visiting and professional support	0.756	4th	0.741	4th	0.6	4th	6
29	Lack of clarity in responsibility Definition	0.722	5th	0.741	4th	0.6	4th	7

The rank of major causes of quality performance problems in aluminum installation works of the 19 projects under MUHFGBCPO are shown in Table.4.3. In accordance of their effects. Accordingly, careless erection techniques used by aluminum installers, measurements taken before predecessor works completed or dimensions used from drawings and layout alignment problem are ranked first.

Inadequate design information from consultant, poor communication between relevant construction parties and lack of involvement of main contractor are ranked second. Improper method of measurement ranked third. Lack of descriptive working drawings is ranked fourth. Unavailability of skilled man power from market is ranked fifth. Cleaning and protection problem (Negligence by work force during other activities), poor application of sealant and lack of profile protection with protective tapes are ranked sixth. Lack of sampling and testing procedures, damaged material during transportation to project site are ranked seventh. Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material, materials damages due to poor handling and storage, damaged material during storing on site and during installation, lack of proper alignment of the primary support frame for the glazing work and misunderstanding the project's deliverables by the production and installation teams are ranked eighth with the least effect on the quality of aluminum works when compared with the others.

4.5 Improvement Factors

4.5.1 Time Related improvement factors

Analysis using Likert's scale data for Aluminum work Subcontractors, contractors, and consultants and their relative importance indices (RII) and the rank of improvement methods to minimize the delay are shown in the Tables G, H, and I in the appendix B respectively.

The group analysis is shown below in Table.4.4.

Table 4.4. Time related improvement factors for the group view

No.	Improvements to minimize delay	Aluminum Workers		Contractor		Consultant		Overall
		RII	Rank	RII	Rank	RII	Rank	Rank
1	Prevent/ Minimize human errors	0.9	1st	0.906	1st	0.96	1st	1
2	Using optimization software for quantifying	0.9	1st	0.906	1st	0.96	1st	1
3	Use CNC machines for fast and precise production	0.9	1st	0.906	1st	0.96	1st	1
4	Engaging 'key parties' at the planning stage	0.9	1st	0.906	1st	0.96	1st	1
5	Training to Aluminum production and installation team	0.889	1st	0.906	1st	0.96	1st	2
6	Organize a qualified team	0.889	1st	0.906	1st	0.96	1st	2
7	Adequate coordination between procurement, production and installation works	0.889	1st	0.906	1st	0.96	1st	2
8	Effective and Integrated work plan for site activities	0.889	1st	0.906	1st	0.96	1st	2
9	Practice of demonstrating the flow of work and deliverables using mockups	0.889	1st	0.906	1st	0.96	1st	2
10	Assign workforces based on their expertise	0.889	1st	0.906	1st	0.9	1st	3
11	Practice of developing suitable production and installation techniques in line with the technology	0.889	1st	0.906	1st	0.88	2nd	4
12	Prepare optimum working window-door openings during construction	0.789	3rd	0.8	3rd	0.96	1st	5
13	Avoid chiseling works	0.789	3rd	0.8	3rd	0.96	1st	5
14	Proper alignment and smooth installation	0.789	3rd	0.8	3rd	0.96	1st	5
15	Applying effective performance and control system	0.833	2nd	0.765	5th	0.88	2nd	6
16	Easy access to movement of pre-assembled units around site	0.789	3rd	0.8	3rd	0.72	3rd	7
17	improve capacity of material management system	0.789	3rd	0.8	3rd	0.72	3rd	7
18	Collaboration/ partnering between involved parties	0.789	3rd	0.8	3rd	0.72	3rd	7
19	ensure consistent supply of project material	0.789	3rd	0.8	3rd	0.667	3rd	8
20	proper storage and delivery of fabricated products	0.789	3rd	0.8	3rd	0.667	3rd	8
21	Avoid Machinery accidents	0.689	4th	0.718	4th	0.72	4th	9

The improvements minimize delay of aluminum work construction suggested by respondents are indicated in the Table 4.4.above.

Accordingly, Prevent/ Minimize human errors, using optimization software for quantifying and Use CNC machines for fast and precise production and engaging 'key parties' at the planning stage are ranked first. Training to Aluminum production and installation team, Organize a qualified team, adequate coordination between procurement, production and installation works, Effective and Integrated work plan for site activities and Practice of demonstrating the flow of work and deliverables using mockups are ranked second. Assign workforces based on their expertise is ranked third. Practice of developing suitable production and installation techniques in line with the technology fourth. Prepare optimum working window-door openings during construction, Avoid chiseling works, Proper alignment and smooth installation are ranked fifth. Applying effective performance and control system is ranked sixth. Easy access to movement of pre-assembled units around site, improve capacity of material management system and Collaboration/ partnering between involved parties are ranked seventh. Ensure consistent supply of project material and proper storage and delivery of fabricated products are ranked eighth and Avoid Machinery accidents is ranked ninth.

4.5.2 Quality related improvement factors

Rank of Improvements to minimize poor quality aluminum works by Aluminum work subcontractors, contractors, and consultants using the relative importance indices are shown in the tables J, K, and L in Appendix B respectively.

The group analysis is shown below in Table 4.5.

Table 4.5 Quality related improvement factors based on the group view

No.	Improvements to minimize poor quality aluminum works	Aluminum worker		Contractor		Consultant		Overall
		RII	Rank	RII	Rank	RII	Rank	Rank
1	Protect materials from scratching. (Cover profiles with protection tape)	0.9	1st	0.92	1st	0.8	1st	1
2	Perform pre-installation survey for assessment of required openings as per the design specification	0.9	1st	0.92	1st	0.8	1st	1
3	Assign respected skill workforce for various activities	0.9	1st	0.92	1st	0.8	1st	1
4	Organize a qualified team	0.9	1st	0.92	1st	0.8	1st	1
5	Avoid careless erection techniques	0.889	1st	0.87	2nd	0.76	2nd	2
6	Use proper handling and storage of profiles and accessories	0.867	2nd	0.77	5th	0.56	5th	3
7	Perform water tightness test for assuring the quality of work	0.856	2nd	0.87	2nd	0.76	2nd	4
8	Quality assurance and quality management	0.867	2nd	0.87	2nd	0.72	3rd	4
	as per prefabrication checklist	0.867	2nd	0.87	2nd	0.72	3rd	4
	as per the mockup	0.867	2nd	0.87	2nd	0.72	3rd	5
10	Educating and training workforce within the organization	0.867	2nd	0.87	2nd	0.6	2nd	6
9	Collaboration/ partnering between involved parties	0.8	3rd	0.8	3rd	0.6	3rd	7
12	Performing post project reviews/ Evaluations for feed back	0.778	4th	0.79	4th	0.6	4th	8
11	Industry wide collaboration on establishing standard training on Aluminum works installation.	0.722	5th	0.74	6th	0.6	6th	9

The Quality improvement factors suggested by respondent are indicated in the Table 4.5. Above. Accordingly, Protect materials from scratching (cover profiles with protection tape), perform pre-installation survey for assessment of required openings as per the design specification, assign respected skill workforce for various activities and organize a qualified team are ranked first. Avoid careless erection techniques is ranked second. Use proper handling and storage of profiles and accessories is ranked third.

Perform water tightness test for assuring the quality of work, quality assurance and quality management as per prefabrication checklist are ranked fourth. Quality assurance and quality management as per the mockup is rated fifth, Educating and training workforce within the organization is rated sixth, Collaboration/ partnering between involved parties is rated seventh, Performing post project reviews/ evaluations for feedback is rated eighth, Industry wide collaboration on establishing standard training on aluminum works installation is ranked ninth.

4.6 Agreement analysis

4.6.1 Agreement Analysis on Causes of Delay

The Spearman's rank correlation coefficient (ρ) was used to show the degree of agreement between the rankings of any two parties. The Spearman's rank correlation is a non-parametric test. Non-parametric tests are also referred to as distribution-free tests. These tests do not require the assumption of normality or the assumption of homogeneity of variance. They compare medians rather than means and, as a result, if the data include one or two outliers, their influence is excluded. The Spearman's rank correlation coefficient (ρ) was calculated as follows:

$$\rho = 1 - \frac{6\Sigma d^2}{n\,(n^2-1)}$$

Where:

d = the difference between the ranks given by any two respondents for an individual cause and

n = the number of causes or groups, which in this case is 29 causes or 8 groups.

Agreement analysis on causes related to delay between Aluminum works subcontractors and contractors, Aluminum works subcontractors and consultants, and consultants and contractors are shown in the tables A, B, and C in Appendix C respectively.

The rank correlation coefficients for the causes of delay are 0.99, 0.99, and 0.99 for Contractor and Aluminum workers, Contractors and consultants and Aluminum workers and consultants respectively. This shows high agreement between rankings because ρ value between 0.8-1 shows very strong agreement between respondents.

4.6.2 Agreement Analysis on Causes of Poor Quality

n = the number of causes or groups, which in this case is 22.

The agreement analysis on causes related to poor quality between Aluminum works subcontractors and contractors, Aluminum works subcontractors and consultants, and consultants and contractors are shown in the tables D, E, and F in Appendix C respectively.

The rank correlation coefficients for the causes of poor quality are 1, 0.99, and 0.99 For Contractor and Aluminum workers, Contractors and consultants and Aluminum workers and consultants respectively. This shows high agreement between rankings because ρ value between 0.8-1 shows very strong agreement between respondents.

4.6.3 Agreement Analysis on the Improvements of Time performance

n = the number of causes or groups, which in this case is 21 causes.

The agreement analysis on causes related to time performance improvement between Aluminum works subcontractors and contractors, Aluminum works subcontractors and consultants, and consultants and contractors are shown in the tables G, H, and I in Appendix C respectively.

The rank correlation coefficients for the improvements of time performance are 0.995, 0.992, and 0.987 for Contractor and Aluminum workers, Contractors and consultants and Aluminum workers and consultants respectively. This shows high agreement between rankings because ρ value between 0.8-1 shows very strong agreement between respondents.

4.6.4 Agreement Analysis on the Improvements of Quality

n = the number of causes or groups, which in this case is 14 causes.

The agreement analysis on causes related to improvement of poor quality between Aluminum works subcontractors and contractors, Aluminum works subcontractors and consultants, and consultants and contractors are shown in the tables J, K, and L in Appendix C respectively.

The rank correlation coefficients for the improvements of quality performance are 0.95, 0.95, and 0.81 for Contractor and Aluminum workers, Contractors and consultants and Aluminum workers and consultants respectively. This shows high agreement between rankings because ρ value between 0.8-1 shows very strong agreement between respondents.

4.7 Findings and Analysis of Interviews and Case Studies

For more information and better understanding on the causes of the problems on the delay and poor quality works on the aluminum installation works, two project managers and two management members from two projects each at finishing stage were selected to be interviewed. For the desk study two projects, one completed and another in the finishing stage were selected. Finally, the findings will be analyzed to select the ones to be included in the list of major causes found using the survey result.

4.7.1 Findings and Analysis of Interviews

Table 4.6. Results of Interview

No	Questions	Interviewee A (Management members)	Interviewee B (Project Managers)
1	What is your experience your overall evaluation on the Aluminum installation projects performance in your project.	• Generic response, supporting that Aluminum installation work is having a problem of quality and time.	• Generic response, supporting that Aluminum installation work is having a problem of quality and time.
2	Major causes of Aluminum works in the building construction not to perform the project in the specified time (Timely Performing problem)	• Design changes and modifications • Delay in approval of material & shop drawing • Inadequate coordination of resources • Lack of communication between involved parties • Disorganized delivery system • Lack of specific material • Shortage of skilled workshop technicians • Lack of defined work procedure • Using manual designing system • Lack of technological awareness • Discrepancy between BOQ and Drawing	• Lack of details from drawings and descriptions • Variation between BOQ and actual • repeated change in shop drawings • No enough skilled manpower available • Delay in consultant response • layout alignment problem(during installation) • Rare site visiting and professional support

No	Questions	Interviewee A (Management members)	Interviewee B (Project Managers)
3	Problem not to meet the required quality of Aluminum window –doors and curtain walls installed in MUHFGBPO (Quality Performance)	• Lack of experience in Aluminum works • Inadequate design information from consultants • unfinished predecessor works • Cleaning and protection problem of installed frames • Improper method of measurement • Lack of Sampling and Testing procedures • Weak installation crew formation • Backward workshop machineries and tools • Design complexity	• Lack of descriptive working drawings • Inadequate Material identification and quantifying • resulting in replacing of original material with substandard material • No enough skilled manpower available on Aluminum works • Lack of commitment by involved parties
4	Your opinion to improve the timely performance in Aluminum installation works (Timely Performance Improvement)	• continuous training of skilled employees • Applying effective performance and control systems • Using optimization software for quantifying • Effective and integrated work plan for site activities. • Engaging 'key parties' at planning stage	• preparation, material request and ordering shall be coordinated • Practice of developing suitable production and installation techniques in line with the technology • Applying incentive techniques to workshop and installation technicians
5	What is your suggestion to improve the quality of Aluminum works in the emerging MUHFGBPO? (Improvement on Quality performance)	• Organize a qualified team of installers • Perform pre-installation survey for assessment of required openings as per the design specification • involve experienced technical crew during preparation of shop drawings • Attain quality product as per the mockup	• continuous training of skilled workforce • Protect materials from scratching. • improve Quality control system on installation work,

As shown Table.4.9. The interview conducted, eighteen answers on Timely Performance issues, Fifteen Quality Performance related answers, eight Timely Performance Improvement answers and eight answers on the Improvements on Quality performance questions were identified.

These points were merged and checked if they were out of the literatures in order to include them in the analysis. The findings from the interview revealed that Design changes and modifications, delay in approval of material & shop drawings, inadequate coordination of resources, lack of communication between involved parties are the causes which contribute to the occurrence of Timely Performance.

As identified from the interview, the impacts of Quality Performance, lack of experience, using semi-automated machines, inadequate design information from consultant, unfinished predecessor works, cleaning and protection problem, improper method of measurement, lack of Sampling and testing procedures, weak installation technicians assigning method, backward workshop machineries and tools and design complexity are also identified as the major causes for the problems of low quality performances.

The interviewee suggested that continuous training of skilled employees Applying effective performance and control systems using optimization software for quantifying effective and integrated work plan for site activities and engaging ‘key parties’ at planning stage are the suggested factors to improve the time and quality issues for the Aluminum work projects.

4.7.2 Findings and Analysis of the Desk Study

Investigations were made through desk study on two selected projects namely: Urban Integrated Land Information Development Agency (2B+G+12) and Federal Supreme Court Judges apartment building (2B+G+18). The analysis of the case study is presented under the subsequent sections. The data and information taken from each project is based on their Aluminum work installation process, procedure, progress report and controlling systems.

Table 4.7. Desk Study Analysis Federal Supreme Court Judges apartment building 2B + G + 18.

Area of Focus	Root Causes for Quality and Timely Performance	Improvements for Time and Quality Problems
1. Design review problem (Preparation and scope identification delay)	• Lack of details from drawings and descriptions • Variation between BOQ and actual • Delayed response for clarification request • Lack of skilled manpower	• Prepare scope of project timely • Develop request method • Train staff to fill the skill gap • Proper change management
2. Window Door schedule preparation problem (Delay in preparation of shop drawing)	• delay in response of consultants to clarify missing information • shortage of technical staff • Weak collaboration with the installer	• critical follow up and request of details to consultants, • Train staff to fill the skill gap
3. Problems on approval of samples, accessories, materials and shop drawings	• Delay in consultant response • delay in follow up	• Strict follow up to consultant,
4. Materials and accessories delivery problem	• Shortage of budget, • Installer is responsible	
5. production problem (QA/QC)	• Requires mockup for reference	
6. Installation problem (Delay and Quality problem)	• execution problem according to measurement, • shortage of skilled manpower • sub-standard scaffoldings • unfinished predecessor works	• improve Quality control system on installation work, • critical follow up to improve measurement accuracy and site readiness
7. Cleaning and protection problem	• Negligence by work force during other activities • Lack of QA/QC/QM	• Improve QA/QC/QM techniques

The result of the desk study, as shown in Table.4.10. The major reasons for the delay (Problem in Timely Performance) of projects are: delay in consultant response, Lack of details from drawings and descriptions, Variation between BOQ and actual, Shortage of technical staff, and Weak collaboration with the installer. The major reasons for quality problems are also identified as: Lack of skilled manpower, Negligence by work force during other activities, and Lack of QA/QC/QM.

The analysis also prevails that, the improvements for the quality and timely performance. Accordingly, factors identified to improve the problems of timely performances are: Preparing proper project scope, Proper change management, Training the staff. For the quality improvement, the followings were identified: Improve QA/QC/QM techniques, Training workforce, and critical follow up to improve measurement accuracy and site readiness.

Table 4.8.Desk Study Analysis Integrated Land Information Development Agency 2B+G+12

Area of Focus	**Root Causes for Quality and Timely Performance**	**Improvements for Time and Quality Problems**
1. Design review problem (Preparation and scope identification delay)	• Lack of details from drawings and descriptions • Variation between BOQ and actual • Delayed response for clarification request • Lack of skilled manpower	• Prepare scope of project timely • Develop request method • Train staff to fill the skill gap • Proper change management
2. Window Door schedule preparation problem (Delay in preparation of shop drawing)	• delay in response of consultants to clarify missing information • shortage of technical staff	• critical follow up and request of details to consultants, • Train staff to fill the skill gap

Area of Focus	Root Causes for Quality and Timely Performance	Improvements for Time and Quality Problems
3. Approval of sample, accessories, materials and shop drawings problem	• Delay in consultant response • delay in communicating to import samples from outside • repeated change in shop drawings • delay in follow up	• communicate supplier for importing materials at the start, • involve experienced technical crew during preparation of shop drawings,
4. Materials and accessories delivery problem	• Shortage of budget, • delay in release of LC, • lengthy process of importing and custom clearance,	• Budget preparation, material request and ordering shall be coordinated, • lead time for the process of LC, importing and custom plan should be prepared accordingly,
5. production problem	• shortage of skilled production manpower • manual designing system • semi-automated machines	• continuous training of skilled employees • Deploy in production QC • Use proper design software • Use modern machines
6. Installation problem	• execution problem according to measurement, • layout alignment problem, • shortage of skilled manpower • sub-standard scaffoldings • unfinished predecessor works • importing prefabricated glazing material	• improve Quality control system on installation work, • critical follow up to improve measurement accuracy, • Continuous training for installation workforce. • Site readiness assessment and verification of predecessor works like thresh holdings, concrete work and alignment • Encourage local production of tempering and glass processing
7. Cleaning and protection problem	• Negligence by work force during other activities • Lack of QA/QC/QM	• Improve QA/QC/QM techniques

The result of the desk study performed with the Aluminum works contractor also prevails that, as shown in Table.4.11. the major reasons for the delay (Problem in Timely Performance) of projects are: Lack of details from drawings and descriptions, Variation between BOQ and actual, Delayed response for clarification request, Repeated change in shop drawings, Shortage of technical staff, Shortage of budget, Lengthy process of L/C, Manual designing system, Using semi-automated machineries, and Weak collaboration with the installer. The major reasons for quality problems are also identified as: Lack of skilled manpower, Measurement accuracy problem, laying out problem, planned execution problems, Negligence by work force during other activities, and Lack of QA/QC/QM.

The analysis also prevails that, the improvements for the quality and timely performance. Accordingly, factors identified to improve the problems of timely performances are:

Preparing proper project scope, involving experienced technical crew during preparation of shop drawings, Proper change management, Training the staff. For the quality improvement, the followings were identified: Improve QA/QC/QM techniques, Training workforce, Use proper design software, Use modern (CNC) workshop machines, Use mockups for controlling deliverables, and critical follow up to improve measurement accuracy and site readiness.

4.8 Summary of Findings and Analysis

Summary of observation obtained from the study is presented below in each category.

4.8.1 Major Cause for low Timely Performance

The major causes for the delay of aluminum works in the public buildings under MUDHFGBCPO are:

Inadequate work plan preparation at the initial stage, inadequate coordination of resources, Lack of clearly defined responsibility, Project scope and specification change, Inadequate resource availability, Delay in approval of material & shop drawing, Lack of defined procedure, Using manual design system, Lack of technological awareness, Lack of details from drawings and descriptions, layout alignment problem (during installation), Lengthy process of L/C and Shortage of budget.

4.8.2 Major causes for projects Quality problems

The major causes for poor quality services and products are: Inadequate design information from consultant, Lack of adopting appropriate software, Layout alignment problem, Lack of Sampling and Testing procedures, lack of descriptive working drawings, Cleaning and protection problem, Measurements taken before predecessor works completed or dimensions used from drawings, Misunderstanding the projects' deliverables by the production and installation teams, Careless erection techniques used by Aluminum installers, Improper method of measurement, Design complexity, Backward workshop machineries and tools, Lack of QA/QC/QM and planned execution problems

4.8.3 Factors to improve Timely Performance

Factors selected to improve the timely performance are: Effective and integrated work plan for site activities, Prevent/Minimize human errors, Practice of demonstrating the flow of work and deliverables using mockups, Practice of developing suitable production and installation techniques in line with the technology, Applying effective performance and control systems, Using optimization software for quantifying, Engaging ‘key parties’ at planning stage, preparation, material request and ordering shall be coordinated, Practice of developing suitable production and installation techniques in line with the technology and Proper change management

4.8.4 Factors to improve Quality Problems

The quality improvement factors chosen are: Assign the respected skilled workforce for various activities, Perform pre-installation survey for assessment of required openings as per the design specification, Employ Quality assurance and / or quality management systems, Collaboration/ partnering between involved groups, Use proper handling and storage of profiles and accessories, Protect materials from scratching. (cover profiles with protection tape), Improve QA/QC/QM techniques, Use proper design software, Use modern (CNC) workshop machines, Use mockups for controlling deliverables and critical follow up to improve measurement accuracy and site readiness

CHAPTER V

5 CONCLUSION AND RECOMMENDATION

The conclusions and recommendations are drawn based on the analysis of findings contained in this research work. The research results are obtained from both desk study and survey study focusing on the objectives of the research. Improvement techniques recommendations will also be forwarded to improve the quality of aluminum installation works and the delay on execution projects for the construction projects under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project office and other similar projects in the future.

5.1 Conclusion

The result of the study pointed out that most of the hindrances to attaining of quality products and services and failure to accomplish projects in time in the Aluminum installation works is the lack of enough knowledge in the areas of design, material selection, fabrication, and installation processes. Further to this, it came to light that the potential barriers to the attainment of project quality and timely performance among Aluminum work construction firms under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office are: inadequate work plan preparation at the initial stage, inadequate coordination of resources, lack of clearly defined responsibility, project scope and specification change, inadequate resource availability, delay in approval of material & shop drawings, lack of technological awareness, inadequate design information from consultant, lack of adopting appropriate software, lack of details from drawings and descriptions, layout alignment problem (during installation), lengthy process of L/C and Shortage of budget.

Similarly, in curbing the above mentioned potential barriers, the study revealed that, the followings as measures for effective improvement of project quality and timely performing methods are: effective and integrated work plan for site activities, developing practice of suitable production and installation techniques in line with the technology, assigning the respected skilled workforce for various activities, performing pre-installation survey for assessment of required openings as per the design specification, are few to mention.

5.2 Recommendations

The research recommended that Aluminum work construction companies should create a flexible and conducive organizational atmosphere which encourages the development of Detail design/ shop drawings preparation using appropriate software, Perform pre-installation survey for assessment of required openings as per the design specification, Improved working conditions (health and safety) clean and organized site, Developing suitable production and installation techniques to match off-site and on-site works, Use modern workshop machines, use appropriate system of aluminum installation method to speed up and quality control, use mockups for controlling deliverables, quality management practices in all aspect of their work.

5.3 Recommendation for Future Research

The researcher would like to suggest for future research that are related with this study are:

1. Aluminum construction firms should be encouraged to apply training programs and refresher courses in Quality and Time Management programs to improve Project Management, Delivery process techniques, and quality management techniques during the execution of aluminum installation projects.

2. Further study should also be encouraged to establish whether the findings can be generalized for other projects of aluminum works.

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APPENDIX - A – Questionnaire

QUESTIONNAIRE ON "Causes for poor quality and delay in aluminum works of public buildings under the Ministry of Urban Development & Housing, and Federal Government Buildings Construction Project Office in Addis Ababa."

PREFACE:

Aluminum construction work in our country has not reached at the satisfactory level both in terms of quality and time taken to finish the work.

The survey is therefore to identify the major causes of the problems for the research under progress.

The result of the study will be used to identify solutions to the problems and also to recommend improvement techniques on the major activities.

OBJECTIVE OF THE STUDY:

1. ***To know more about the current application of aluminum and its future trend in the construction industry and***
2. ***To identify the major causes of the problems in the construction process not to meet the required quality and not to finish the works in the given time.***
3. ***To study the cause of the problems and recommend improvement techniques on the major activities.***

The research is conducted under ERA's sponsored specialization program at Addis Ababa Science and Technology Collage (AASTU) under the supervision of Dr. Wubishet Jekale.

Please note that all data and information are strictly confidential and will not be disclosed, it is only for academic study purposes. For any information please contact me with the following address Mulualem Merid, Phone No. 091-2627 268 /0930-106393and E mail mamemerid@yahoo.com

Thank you for your time and kind cooperation.

SECTION 1:

PERSONAL AND ORGANIZATIONAL PROFILE OF RESPONDANT

Please fill in the blank or tick (√) in the box as shown.

1. Organization / Company Name : _______________

2. Years since establishment:

☐ <5 years ☐5-10 years ☐10-15 years ☐15-20 years ☐>20years

3. Organization's area of specialization:

☐ Building ☐ Consultant ☐ Aluminum Works ☐ Finishing Works

Other (Please specify) ____

4. Your job role:

☐ Manager ☐ Project Manager ☐ Planning and Controller ☐ R & D ☐ Team Leader ☐ Supervisor ☐ Quality Controller ☐ Designer ☐ Workshop Technician ☐ Installation Technician

5. Your Experience:

☐ <5 years ☐5-10 years ☐>10 years

6. Your Name, Title and Contact Address:

Name (Optional): ______________________________

Job Title: ______________________________

Contact Address (Optional) E-mail: ________________________Tel: _________

SECTION 2-GENERAL QUESTIONS

1. Is there any delay on the aluminum works of your project?

   Yes ☐ No ☐ nothing to say ☐

2. Is there a quality problem on the aluminum works of your project?

   Yes ☐ No ☐ nothing to say ☐

SECTION 3- SURVEY QUESTIONNAIRES

Causes for delay in aluminum works

Please rate the impact of the following problems on a scale of 1 – 5:1 being the least impacting and 5 being the most impacting:

No.	Causes related to delay	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
1	Inadequate Work Plan preparation at the Initial Stage					
	Delay in approval of material and shop drawing					
	Shorter procurement lead time					
	Lack of proper fabrication planning					
	Dis organized delivery system					
	Unauthorized installation and fabrication					
	Glazing and sealing simply follows installation of frame					
2	Project's Scope and specification change					
	Lack of technological awareness at the design stage					
	Lack of details from drawings and descriptions					
	Variation between BOQ and actual					
	Design change					
	Lack of specific material					
3	Insufficient Support from top Management					
	Delayed response for reported problems					
	Weak or no training program					

	Poor workforce engagement strategy					
	Un-even performance evaluation					
	Rare site visiting and professional support					
4	Inadequate Resource availability					
	Weak inventory control					
	Lengthy process of improving					
	No enough skilled manpower available					
	Backward workshop machineries and tools					
5	Inadequate Coordination of Resources					
	Weak installation technicians assigning method					
	Weak crew formation					
	Weak project material handling					
	Disorganized fleet management					
6	Lack of Commitment by Involved Parties					
	Site engineer, Forman, time keeper					
7	Lack of clarity in responsibility Definition					
8	Lack of Involvement of Main Contractor					
	Weak coordination					
	Weak communication					
	Lack of defined procedure					

Causes for poor quality in aluminum works

Please rate the impact of the following problems on a scale of 1 – 5: 1 being the least impacting and 5 being the most impacting:

No	Causes related to poor quality	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
1	Misunderstanding the projects' deliverables by the production and installation teams					
2	Inadequate design information from consultant					
3	Poor communication between relevant construction parties					
4	Lack of involvement of main contractor					
5	Technical incompetence and limited personal experience of main contractor on aluminum works					
6	Careless erection techniques used by aluminum installers					
7	Lack of adopting appropriate design and optimization software					
8	Unavailability of skilled man power from market					
9	Using sub-standard scaffolding					
10	Measurements taken before predecessor works completed or dimensions used from drawings					
11	Cleaning and protection problem (Negligence by work force during other activities)					
12	Lack of descriptive working drawings					
13	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material					
14	Materials damages due to poor handling and storage					
15	Poor application of sealant					
16	Lack of profile protection with protective tapes					
17	Lack of sampling and testing procedures					
18	Improper method of measurement					
19	Layout alignment problem					
20	Damaged material during transportation to project site					
21	Damaged material during storing on site and during installation					
22	Lack of proper alignment of the primary support for the glazing					

Improvement to minimize delay in aluminum works

Please rate the impact of the following problems on a scale of 1 – 5: 1 being the least impacting and 5 being the most impacting:

No.	**Improvements to minimize delay**	Strongly agree 5	Agree 4	Neutral 3	Disagree 2	Strongly disagree 1
1	Training to Aluminum production and installation team					
2	Prepare optimum working window-door openings during construction					
	Avoid chiseling works					
	Proper alignment and smooth installation					
3	Prevent/ Minimize human errors					
	Using optimization software for quantifying					
	Use CNC machines for fast and precise production					
4	Avoid Machinery accidents					
5	Organize a qualified team					
	Assign workforces based on their expertise					
	Use outsourcing for best performance					
6	Applying effective performance and control system					
7	Easy access to movement of pre-assembled units around site					
8	Applying incentive techniques to workshop technicians					
9	improve capacity of material management system					
	ensure consistent supply of project material					
	proper storage and delivery of fabricated products					
10	Adequate coordination between procurement, production and installation works					
11	Effective and Integrated work plan for site activities					
12	Collaboration/ partnering between involved parties					
13	Engaging 'key parties' at the planning stage					
14	Effective communication across the involved groups					
15	Practice of demonstrating the flow of work and deliverables using mockups					
16	Practice of developing suitable production and installation techniques in line with the technology					

Improvement to minimize poor quality in aluminum works

Please rate the impact of the following problems on a scale of 1 – 5: 1 being the least impacting and 5 being the most impacting:

No	Improvements to minimize poor quality aluminum works	Strongly agree	Agree	Neutral	Disagree	Strongly disagree
		5	4	3	2	1
1	Protect materials from scratching. Cover profiles with protection tape)					
2	Perform pre-installation survey for assessment of required openings as per the design specification					
3	Assign respected skill workforce for various activities					
4	Organize a qualified team					
5	Avoid careless erection techniques					
6	Use proper handling and storage of profiles and accessories					
7	Perform water tightness test for assuring the quality of work					
8	Quality assurance and quality management					
	as per prefabrication checklist					
	as per the mockup					
9	Collaboration/ partnering between involved parties					
10	Educating and training workforce within the organization					
11	Industry wide collaboration on establishing standard training on Aluminum works installation.					
12	Performing post project reviews/ Evaluations for feed back					

Section 4 Case Study Interview Question

From your experience please briefly describe on the following issues:

1. Your overall evaluation on the Aluminum installation projects performance in our country.
2. Major causes of Aluminum works in the building construction not to perform the project in the specified time (Timely Performance)
3. Problem not to meet the required quality of Aluminum window –doors and curtain walls installed in the high-rising public buildings of Addis Ababa (Quality Performance)
4. Your opinion to improve the timely performance in Aluminum installation works (Timely Performance Improvement)
5. What is your suggestion to improve the quality of Aluminum works in the emerging high-rising buildings? (Improvement on Quality performance)

APPENDIX B–Analysis of importance index and rank

Table. A. Analysis on causes of delay in Aluminum works from contractors view

No.	Causes related to delay	RII	Rank
1	Inadequate Work Plan preparation at the Initial Stage	0.894	1st
	Delay in approval of material and shop drawing	0.894	1st
	Shorter procurement lead time	0.894	1st
	Lack of proper fabrication planning	0.894	1st
	Dis organized delivery system	0.894	1st
	Unauthorized installation and fabrication	0.894	1st
	Glazing and sealing simply follows installation of frame	0.894	1st
2	Project's Scope and specification change	0.894	1st
	Lack of technological awareness at the design stage	0.894	1st
	Lack of details from drawings and descriptions	0.894	1st
	Variation between BOQ and actual	0.894	1st
	Design change	0.894	1st
	Lack of specific material	0.894	1st
5	Inadequate Coordination of Resources	0.894	1st
	Weak installation technicians assigning method	0.894	1st
	Weak crew formation	0.894	1st
	Weak project material handling	0.882	1st
	Disorganized fleet management	0.894	1st
8	Lack of Involvement of Main Contractor	0.835	2nd
	Weak coordination	0.835	2nd
	Weak communication	0.835	2nd
	Lack of defined procedure	0.835	2nd
4	Inadequate Resource availability	0.788	3rd
	Weak inventory control	0.788	3rd
	Lengthy process of importing	0.788	3rd
	No enough skilled manpower available	0.788	3rd
	Backward workshop machineries and tools	0.788	3rd
6	Lack of Commitment by Involved Parties	0.788	3rd
	Site engineer, Forman, time keeper	0.788	3rd
3	Insufficient Support from top Management	0.741	4th
	Delayed response for reported problems	0.741	4th
	Weak or no training program	0.741	4th
	Poor workforce engagement strategy	0.741	4th
	Un-even performance evaluation	0.741	4th
	Rare site visiting and professional support	0.741	4th
7	Lack of clarity in responsibility Definition	0.741	4th

Table. B. Analysis on causes of delay in Aluminum works from consultants view

No.	Causes related to delay	RII	Rank
1	Inadequate Work Plan preparation at the Initial Stage	0.880	1st
	Delay in approval of material and shop drawing	0.880	1st
	Shorter procurement lead time	0.880	1st
	Lack of proper fabrication planning	0.880	1st
	Dis organized delivery system	0.880	1st
	Unauthorized installation and fabrication	0.880	1st
	Glazing and sealing simply follows installation of frame	0.880	1st
2	Project's Scope and specification change	0.880	1st
	Lack of technological awareness at the design stage	0.880	1st
	Lack of details from drawings and descriptions	0.880	1st
	Variation between BOQ and actual	0.880	1st
	Design change	0.880	1st
	Lack of specific material	0.880	1st
5	Inadequate Coordination of Resources	0.880	1st
	Weak installation technicians assigning method	0.880	1st
	Weak crew formation	0.880	1st
	Weak project material handling	0.880	1st
	Disorganized fleet management	0.880	1st
4	Inadequate Resource availability	0.840	2nd
	Weak inventory control	0.840	2nd
	Lengthy process of importing	0.840	2nd
	No enough skilled manpower available	0.840	2nd
	Backward workshop machineries and tools	0.840	2nd
8	Lack of Involvement of Main Contractor	0.840	2nd
	Weak coordination	0.840	2nd
	Weak communication	0.840	2nd
	Lack of defined procedure	0.840	2nd
6	Lack of Commitment by Involved Parties	0.760	3rd
	Site engineer, Forman, time keeper	0.760	3rd
3	Insufficient Support from top Management	0.600	4th
	Delayed response for reported problems	0.600	4th
	Weak or no training program	0.600	4th
	Poor workforce engagement strategy	0.600	4th
	Un-even performance evaluation	0.600	4th
	Rare site visiting and professional support	0.600	4th
7	Lack of clarity in responsibility Definition	0.600	4th

Table. C. Analysis on causes of delay in Aluminum works from Installers view

No.	Causes related to delay	RII	Rank
1	Inadequate Work Plan preparation at the Initial Stage	0.878	1st
	Delay in approval of material and shop drawing	0.878	1st
	Shorter procurement lead time	0.878	1st
	Lack of proper fabrication planning	0.878	1st
	Dis organized delivery system	0.878	1st
	Unauthorized installation and fabrication	0.878	1st
	Glazing and sealing simply follows installation of frame	0.878	1st
2	Project's Scope and specification change	0.878	1st
	Lack of technological awareness at the design stage	0.878	1st
	Lack of details from drawings and descriptions	0.867	1st
	Variation between BOQ and actual	0.878	1st
	Design change	0.867	1st
	Lack of specific material	0.878	1st
5	Inadequate Coordination of Resources	0.878	1st
	Weak installation technicians assigning method	0.878	1st
	Weak crew formation	0.878	1st
	Weak project material handling	0.878	1st
	Disorganized fleet management	0.878	1st
4	Inadequate Resource availability	0.833	2nd
	Weak inventory control	0.832	2nd
	Lengthy process of importing	0.833	2nd
	No enough skilled manpower available	0.833	2nd
	Backward workshop machineries and tools	0.833	2nd
8	Lack of Involvement of Main Contractor	0.833	2nd
	Weak coordination	0.833	2nd
	Weak communication	0.833	2nd
	Lack of defined procedure	0.833	2nd
6	Lack of Commitment by Involved Parties	0.778	3rd
	Site engineer, Forman, time keeper	0.778	3rd
3	Insufficient Support from top Management	0.756	4th
	Delayed response for reported problems	0.756	4th
	Weak or no training program	0.756	4th
	Poor workforce engagement strategy	0.756	4th
	Un-even performance evaluation	0.756	4th
	Rare site visiting and professional support	0.756	4th
7	Lack of clarity in responsibility Definition	0.722	5th

Table. D. Analysis on quality issues in Aluminum works from Contractors view

No.	Causes related to poor quality	RII	Rank
10	Measurements taken before predecessor works completed or dimensions used from drawings	0.906	1st
19	Layout alignment problem	0.906	1st
2	Inadequate design information from consultant	0.882	2nd
3	Poor communication between relevant construction parties	0.882	2nd
4	Lack of involvement of main contractor	0.882	2nd
18	Improper method of measurement	0.882	2nd
8	Unavailability of skilled man power from market	0.800	3rd
12	Lack of descriptive working drawings	0.800	3rd
5	Technical incompetence and limited personal experience of main contractor on aluminum works	0.718	4th
7	Lack of adopting appropriate design and optimization software	0.718	4th
9	Using sub-standard scaffolding	0.718	4th
11	Cleaning and protection problem (Negligence by work force during other activities)	0.718	4th
15	Poor application of sealant	0.718	4th
16	Lack of profile protection with protective tapes	0.718	4th
17	Lack of sampling and testing procedures	0.718	4th
20	Damaged material during transportation to project site	0.718	4th
13	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	0.624	5th
14	Materials damages due to poor handling and storage	0.624	5th
21	Damaged material during storing on site and during installation	0.624	5th
22	Lack of proper alignment of the primary support for the glazing	0.624	5th
1	Misunderstanding the projects' deliverables by the production and installation teams	0.588	6th

Table. E. Analysis on quality issues in Aluminum works from Consultants view

No.	Causes related to poor quality	RII	Rank
6	Careless erection techniques used by aluminum installers	1.000	1st
10	Measurements taken before predecessor works completed or dimensions used from drawings	1.000	1st
12	Lack of descriptive working drawings	1.000	1st
19	Layout alignment problem	1.000	1st
2	Inadequate design information from consultant	0.960	2nd
3	Poor communication between relevant construction parties	0.960	2nd
4	Lack of involvement of main contractor	0.960	2nd
18	Improper method of measurement	0.857	2nd
8	Unavailability of skilled man power from market	0.880	3rd
8	Unavailability of skilled man power from market	0.880	3rd
5	Technical incompetence and limited personal experience of main contractor on aluminum works	0.760	4th
7	Lack of adopting appropriate design and optimization software	0.760	4th
9	Using sub-standard scaffolding	0.760	4th
11	Cleaning and protection problem (Negligence by work force during other activities)	0.760	4th
15	Poor application of sealant	0.760	4th
16	Lack of profile protection with protective tapes	0.760	4th
17	Lack of sampling and testing procedures	0.760	4th
20	Damaged material during transportation to project site	0.760	4th
13	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	0.560	5th
14	Materials damages due to poor handling and storage	0.560	5th
21	Damaged material during storing on site and during installation	0.560	5th
22	Lack of proper alignment of the primary support for the glazing	0.560	5th
1	Misunderstanding the projects' deliverables by the production and installation teams	0.520	6th

Table. F. Analysis on quality issues in Aluminum works from installers view

No.	Causes related to poor quality	RII	Rank
21	Careless erection techniques used by aluminum installers	0.889	1st
10	Measurements taken before predecessor works completed or dimensions used from drawings	0.889	1st
19	Layout alignment problem	0.889	1st
2	Inadequate design information from consultant	0.856	2nd
3	Poor communication between relevant construction parties	0.856	2nd
4	Lack of involvement of main contractor	0.856	2nd
18	Improper method of measurement	0.856	2nd
8	Unavailability of skilled man power from market	0.778	3rd
12	Lack of descriptive working drawings	0.778	3rd
5	Technical incompetence and limited personal experience of main contractor on aluminum works	0.756	4th
7	Lack of adopting appropriate design and optimization software	0.756	4th
9	Using sub-standard scaffolding	0.767	4th
11	Cleaning and protection problem (Negligence by work force during other activities)	0.767	4th
15	Poor application of sealant	0.767	4th
16	Lack of profile protection with protective tapes	0.767	4th
17	Lack of sampling and testing procedures	0.767	4th
20	Damaged material during transportation to project site	0.767	4th
13	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	0.611	5th
14	Materials damages due to poor handling and storage	0.611	5th
21	Damaged material during storing on site and during installation	0.611	5th
22	Lack of proper alignment of the primary support for the glazing	0.611	5th
1	Misunderstanding the projects' deliverables by the production and installation teams	0.567	6th

Table. G. Time related improvement factors on Aluminum works (installers view)

No.	Improvements to minimize delay	RII	Rank
1	Training to Aluminum production and installation team	0.889	1st
3	Prevent/ Minimize human errors	0.900	1st
	Using optimization software for quantifying	0.900	1st
	Use CNC machines for fast and precise production	0.900	1st
5	Organize a qualified team	0.889	1st
	Assign workforces based on their expertise	0.889	1st
10	Adequate coordination between procurement, production and installation works	0.889	1st
11	Effective and Integrated work plan for site activities	0.889	1st
13	Engaging 'key parties' at the planning stage	0.900	1st
14	Practice of demonstrating the flow of work and deliverables using mockups	0.889	1st
15	Practice of developing suitable production and installation techniques in line with the technology	0.889	1st
6	Applying effective performance and control system	0.833	2nd
2	Prepare optimum working window-door openings during construction	0.789	3rd
	Avoid chiseling works	0.789	3rd
	Proper alignment and smooth installation	0.789	3rd
7	Easy access to movement of pre-assembled units around site	0.789	3rd
9	improve capacity of material management system	0.789	3rd
	ensure consistent supply of project material	0.789	3rd
12	proper storage and delivery of fabricated products	0.789	3rd
4	Collaboration/ partnering between involved parties	0.789	3rd
	Avoid Machinery accidents	0.689	4th

Table. H. Time related improvement factors from contractors view

No.	Improvements to minimize delay	RII	Rank
1	Training to Aluminum production and installation team	0.906	1st
3	Prevent/ Minimize human errors	0.906	1st
	Using optimization software for quantifying	0.906	1st
	Use CNC machines for fast and precise production	0.906	1st
5	Organize a qualified team	0.906	1st
	Assign workforces based on their expertise	0.906	1st
10	Adequate coordination between procurement, production and installation works	0.906	1st
11	Effective and Integrated work plan for site activities	0.906	1st
13	Engaging 'key parties' at the planning stage	0.906	1st
14	Practice of demonstrating the flow of work and deliverables using mockups	0.906	1st
15	Practice of developing suitable production and installation techniques in line with the technology	0.906	1st
6	Applying effective performance and control system	0.847	2nd
5	Avoid careless erection techniques	0.871	2nd
7	Perform water tightness test for assuring the quality of work	0.871	2nd
8	Quality assurance and quality management	0.871	2nd
	as per prefabrication checklist	0.871	2nd
	as per the mockup	0.871	2nd
10	Educating and training workforce within the organization	0.871	2nd
2	Prepare optimum working window-door openings during construction	0.800	3rd
	Avoid chiseling works	0.800	3rd
	Proper alignment and smooth installation	0.800	3rd
7	Easy access to movement of pre-assembled units around site	0.800	3rd
9	improve capacity of material management system	0.800	3rd
	ensure consistent supply of project material	0.800	3rd
	proper storage and delivery of fabricated products	0.800	3rd
12	Collaboration/ partnering between involved parties	0.800	3rd
9	Collaboration/ partnering between involved parties	0.800	3rd
4	Avoid Machinery accidents	0.718	4th
12	Performing post project reviews/ Evaluations for feed back	0.788	4th

Table. I. Time related improvement factors from consultants view

No.	Improvements to minimize delay	RII	Rank
1	Training to Aluminum production and installation team	0.960	1st
2	Prepare optimum working window-door openings during construction	0.960	1st
	Avoid chiseling works	0.960	1st
	Proper alignment and smooth installation	0.960	1st
3	Prevent/ Minimize human errors	0.960	1st
	Using optimization software for quantifying	0.960	1st
	Use CNC machines for fast and precise production	0.960	1st
5	Organize a qualified team	0.960	1st
	Assign workforces based on their expertise	0.900	1st
10	Adequate coordination between procurement, production and installation works	0.960	1st
11	Effective and Integrated work plan for site activities	0.960	1st
13	Engaging 'key parties' at the planning stage	0.960	1st
14	Practice of demonstrating the flow of work and deliverables using mockups	0.960	1st
6	Applying effective performance and control system	0.880	2nd
15	Practice of developing suitable production and installation techniques in line with the technology	0.880	2nd
7	Easy access to movement of pre-assembled units around site	0.720	3rd
9	improve capacity of material management system	0.720	3rd
	ensure consistent supply of project material	0.667	3rd
	proper storage and delivery of fabricated products	0.667	3rd
12	Collaboration/ partnering between involved parties	0.720	3rd
4	Avoid Machinery accidents	0.720	4th

Table .J. Quality improvement factors for aluminum works (installers view)

No.	Improvements to minimize poor quality aluminum works	RII	Rank
1	Protect materials from scratching. Cover profiles with protection tape)	0.900	1st
2	Perform pre-installation survey for assessment of required openings as per the design specification	0.900	1st
3	Assign respected skill workforce for various activities	0.900	1st
4	Organize a qualified team	0.900	1st
5	Avoid careless erection techniques	0.889	1st
6	Use proper handling and storage of profiles and accessories	0.867	2nd
7	Perform water tightness test for assuring the quality of work	0.856	2nd
8	Quality assurance and quality management	0.867	2nd
	as per prefabrication checklist	0.867	2nd
	as per the mockup	0.867	2nd
10	Educating and training workforce within the organization	0.867	2nd
9	Collaboration/ partnering between involved parties	0.800	3rd
12	Performing post project reviews/ Evaluations for feed back	0.778	4th
11	Industry wide collaboration on establishing standard training on Aluminum works installation.	0.722	5th

K. Quality related improvement factors from Contractors view

No.	Improvements to minimize poor quality aluminum works	RII	Rank
1	Protect materials from scratching. Cover profiles with protection tape)	0.918	1st
2	Perform pre-installation survey for assessment of required openings as per the design specification	0.918	1st
3	Assign respected skill workforce for various activities	0.918	1st
4	Organize a qualified team	0.918	1st
5	Avoid careless erection techniques	0.871	2nd
7	Perform water tightness test for assuring the quality of work	0.871	2nd
8	Quality assurance and quality management	0.871	2nd
	as per prefabrication checklist	0.871	2nd
	as per the mockup	0.871	2nd
10	Educating and training workforce within the organization	0.871	2nd
9	Collaboration/ partnering between involved parties	0.800	3rd
12	Performing post project reviews/ Evaluations for feed back	0.788	4th
6	Use proper handling and storage of profiles and accessories	0.765	5th
11	Industry wide collaboration on establishing standard training on Aluminum works installation.	0.741	6th

Table. L. Quality related improvement factors from Consultants view

No.	Improvements to minimize poor quality aluminum works	RII	Rank
1	Protect materials from scratching. Cover profiles with protection tape)	0.800	1st
2	Perform pre-installation survey for assessment of required openings as per the design specification	0.800	1st
3	Assign respected skill workforce for various activities	0.800	1st
4	Organize a qualified team	0.800	1st
5	Avoid careless erection techniques	0.760	2nd
7	Perform water tightness test for assuring the quality of work	0.760	2nd
10	Educating and training workforce within the organization	0.600	2nd
8	Quality assurance and quality management	0.720	3rd
	as per prefabrication checklist	0.720	3rd
	as per the mockup	0.720	3rd
9	Collaboration/ partnering between involved parties	0.600	3rd
12	Performing post project reviews/ Evaluations for feed back	0.600	4th
6	Use proper handling and storage of profiles and accessories	0.560	5th
11	Industry wide collaboration on establishing standard training on Aluminum works installation.	0.600	6th

APPENDIX C – Analysis of correlation coefficient between different respondent

Table .A. Agreement analysis on causes of delay (installers and contractors)

No.	related to delay	Aluminum Workers	Contractor	co-a	d2
		Rank	Rank		
1	Delay in approval of material and shop drawing	1	1	0	0
2	Shorter procurement lead time	1	1	0	0
3	Lack of proper fabrication planning	1	1	0	0
4	Dis organized delivery system	1	1	0	0
5	Unauthorized installation and fabrication	1	1	0	0
6	Glazing and sealing simply follows installation of frame	1	1	0	0
7	Lack of technological awareness at the design stage	1	1	0	0
8	Variation between BOQ and actual	1	1	0	0
9	Lack of specific material	1	1	0	0
10	Weak installation technicians assigning method	1	1	0	0
11	Weak crew formation	1	1	0	0
12	Disorganized fleet management	1	1	0	0
13	Lack of details from drawings and descriptions	1	1	0	0
14	Design change	1	1	0	0
15	Weak project material handling	1	1	0	0
16	Inadequate Resource availability	2	3	1	1
17	Lengthy process of importing	2	3	1	1
18	No enough skilled manpower available	2	3	1	1
19	Backward workshop machineries and tools	2	3	1	1
20	Lack of Involvement of Main Contractor	2	2	0	0
21	Weak communication	2	2	0	0
22	Lack of defined procedure	2	2	0	0
23	Lack of Commitment by Involved Parties	3	3	0	0
24	Site engineer, Forman, time keeper	3	3	0	0
25	Delayed response for reported problems	4	4	0	0
26	Weak or no training program	4	4	0	0
27	Un-even performance evaluation	4	4	0	0
28	Rare site visiting and professional support	4	4	0	0
29	Lack of clarity in responsibility Definition	5	4	-1	1
	S=				5
	co=contractors rank, **a**=aluminum workers rank, **cu**=consultant rank and **d** = difference of ranks			n=	29

ɣ =.99

Table .B. Agreement analysis on causes of delay (installers and consultants)

No.	Improvements to minimize delay	Aluminum Workers	Consultants	co-a	d^2
		Rank	Rank		
1	Prevent/ Minimize human errors	1	1	0	0
2	Using optimization software for quantifying	1	1	0	0
3	Use CNC machines for fast and precise production	1	1	0	0
4	Engaging 'key parties' at the planning stage	1	1	0	0
5	Training to Aluminum production and installation team	1	1	0	0
6	Organize a qualified team	1	1	0	0
7	Adequate coordination between procurement, production and installation works	1	1	0	0
8	Effective and Integrated work plan for site activities	1	1	0	0
9	Practice of demonstrating the flow of work and deliverables using mockups	1	1	0	0
10	Assign workforces based on their expertise	1	1	0	0
11	Practice of developing suitable production and installation techniques in line with the technology	1	2	1	1
12	Prepare optimum working window-door openings during construction	3	1	-2	4
13	Avoid chiseling works	3	1	-2	4
14	Proper alignment and smooth installation	3	1	-2	4
15	Applying effective performance and control system	2	2	0	0
16	Easy access to movement of pre-assembled units around site	3	3	0	0
17	improve capacity of material management system	3	3	0	0
18	Collaboration/ partnering between involved parties	3	3	0	0
19	ensure consistent supply of project material	3	3	0	0
20	proper storage and delivery of fabricated products	3	3	0	0
21	Avoid Machinery accidents	4	4	0	0
	Σ=				13
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	21

ɤ =.99

Table. C. Agreement analysis on causes of delay (contractors and consultants)

No.	Causes related to delay	Consultant	Contractor	co-cu	d2
		Rank	Rank		
1	Delay in approval of material and shop drawing	1	1	0	0
2	Shorter procurement lead time	1	1	0	0
3	Lack of proper fabrication planning	1	1	0	0
4	Dis organized delivery system	1	1	0	0
5	Unauthorized installation and fabrication	1	1	0	0
6	Glazing and sealing simply follows installation of frame	1	1	0	0
7	Lack of technological awareness at the design stage	1	1	0	0
8	Variation between BOQ and actual	1	1	0	0
9	Lack of specific material	1	1	0	0
10	Weak installation technicians assigning method	1	1	0	0
11	Weak crew formation	1	1	0	0
12	Disorganized fleet management	1	1	0	0
13	Lack of details from drawings and descriptions	1	1	0	0
14	Design change	1	1	0	0
15	Weak project material handling	1	1	0	0
16	Inadequate Resource availability	2	3	-1	1
17	Lengthy process of importing	2	3	-1	1
18	No enough skilled manpower available	2	3	-1	1
19	Backward workshop machineries and tools	2	3	-1	1
20	Lack of Involvement of Main Contractor	2	2	0	0
21	Weak communication	2	2	0	0
22	Lack of defined procedure	2	2	0	0
23	Lack of Commitment by Involved Parties	3	3	0	0
24	Site engineer, Forman, time keeper	3	3	0	0
25	Delayed response for reported problems	4	4	0	0
26	Weak or no training program	4	4	0	0
27	Un-even performance evaluation	4	4	0	0
28	Rare site visiting and professional support	4	4	0	0
29	Lack of clarity in responsibility Definition	4	4	0	0
	Σ=				4
	co=contractors rank, **a**=aluminum workers rank, **cu**=consultant rank and **d** = difference of ranks			n=	29

ɤ =.99

Table .D. Agreement analysis on causes for poor quality (installers and Contractors)

No.	Causes related to poor quality	Aluminum worker Rank	Contractor Rank	co-a	d2
1	Careless erection techniques used by aluminum installers	1	1	0	0
2	Measurements taken before predecessor works completed or dimensions used from drawings	1	1	0	0
3	Layout alignment problem	1	1	0	0
4	Inadequate design information from consultant	2	2	0	0
5	Poor communication between relevant construction parties	2	2	0	0
6	Lack of involvement of main contractor	2	2	0	0
7	Improper method of measurement	2	2	0	0
8	Unavailability of skilled man power from market	3	3	0	0
9	Lack of descriptive working drawings	3	3	0	0
10	Technical incompetence and limited personal experience of main contractor on aluminum works	4	4	0	0
11	Lack of adopting appropriate design and optimization software	4	4	0	0
12	Using sub-standard scaffolding	4	4	0	0
13	Cleaning and protection problem (Negligence by work force during other activities)	4	4	0	0
14	Poor application of sealant	4	4	0	0
15	Lack of profile protection with protective tapes	4	4	0	0
16	Lack of sampling and testing procedures	4	4	0	0
17	Damaged material during transportation to project site	4	4	0	0
18	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	5	5	0	0
19	Materials damages due to poor handling and storage	5	5	0	0
20	Damaged material during storing on site and during installation	5	5	0	0
21	Lack of proper alignment of the primary support for the glazing	5	5	0	0
22	Misunderstanding the projects' deliverables by the production and installation teams	6	6	0	0
	Σ=				0
	co=contractors rank, **a**=aluminum workers rank, **cu**=consultant rank and **d**= difference of ranks			n=	22

ɤ =1

Table. E. Agreement analysis on causes of Poor Quality (installers and Consultants)

No.	Causes related to poor quality	Aluminum worker	Consultant	co-a	d2
		Rank	Rank		
1	Careless erection techniques used by aluminum installers	1	1	0	0
2	Measurements taken before predecessor works completed or dimensions used from drawings	1	1	0	0
3	Layout alignment problem	1	1	0	0
4	Inadequate design information from consultant	2	2	0	0
5	Poor communication between relevant construction parties	2	2	0	0
6	Lack of involvement of main contractor	2	2	0	0
7	Improper method of measurement	2	2	0	0
8	Unavailability of skilled man power from market	3	3	0	0
9	Lack of descriptive working drawings	3	1	-2	4
10	Technical incompetence and limited personal experience of main contractor on aluminum works	4	4	0	0
11	Lack of adopting appropriate design and optimization software	4	4	0	0
12	Using sub-standard scaffolding	4	4	0	0
13	Cleaning and protection problem (Negligence by work force during other activities)	4	4	0	0
14	Poor application of sealant	4	4	0	0
15	Lack of profile protection with protective tapes	4	4	0	0
16	Lack of sampling and testing procedures	4	4	0	0
17	Damaged material during transportation to project site	4	4	0	0
18	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	5	5	0	0
19	Materials damages due to poor handling and storage	5	5	0	0
20	Damaged material during storing on site and during installation	5	5	0	0
21	Lack of proper alignment of the primary support for the glazing	5	5	0	0
22	Misunderstanding the projects' deliverables by the production and installation teams	6	6	0	0
	Σ=				4
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	22

ɤ =.99

Table .F. Agreement analysis on causes of poor quality (contractors and consultants)

No.	Causes related to poor quality	Consultant	Contractor	co-a	d2
		Rank	Rank		
1	Careless erection techniques used by aluminum installers	1	1	0	0
2	Measurements taken before predecessor works completed or dimensions used from drawings	1	1	0	0
3	Layout alignment problem	1	1	0	0
4	Inadequate design information from consultant	2	2	0	0
5	Poor communication between relevant construction parties	2	2	0	0
6	Lack of involvement of main contractor	2	2	0	0
7	Improper method of measurement	2	2	0	0
8	Unavailability of skilled man power from market	3	3	0	0
9	Lack of descriptive working drawings	1	3	2	4
10	Technical incompetence and limited personal experience of main contractor on aluminum works	4	4	0	0
11	Lack of adopting appropriate design and optimization software	4	4	0	0
12	Using sub-standard scaffolding	4	4	0	0
13	Cleaning and protection problem (Negligence by work force during other activities)	4	4	0	0
14	Poor application of sealant	4	4	0	0
15	Lack of profile protection with protective tapes	4	4	0	0
16	Lack of sampling and testing procedures	4	4	0	0
17	Damaged material during transportation to project site	4	4	0	0
18	Inadequate material identification and qualifying (profiles, accessories, etc.) resulting in replacing of original material by sub-standard material	5	5	0	0
19	Materials damages due to poor handling and storage	5	5	0	0
20	Damaged material during storing on site and during installation	5	5	0	0
21	Lack of proper alignment of the primary support for the glazing	5	5	0	0
22	Misunderstanding the projects' deliverables by the production and installation teams	6	6	0	0
	Σ=				4
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	22

ɤ =.99

Table. G. Agreement analysis on improvements of delay (installers and contractors)

No.	Improvements to minimize delay	Aluminum Workers	Contractor	co-a	d2
		Rank	Rank		
1	Prevent/ Minimize human errors	1	1	0	0
2	Using optimization software for quantifying	1	1	0	0
3	Use CNC machines for fast and precise production	1	1	0	0
4	Engaging 'key parties' at the planning stage	1	1	0	0
5	Training to Aluminum production and installation team	1	1	0	0
6	Organize a qualified team	1	1	0	0
7	Adequate coordination between procurement, production and installation works	1	1	0	0
8	Effective and Integrated work plan for site activities	1	1	0	0
9	Practice of demonstrating the flow of work and deliverables using mockups	1	1	0	0
10	Assign workforces based on their expertise	1	1	0	0
11	Practice of developing suitable production and installation techniques in line with the technology	1	1	0	0
12	Prepare optimum working window-door openings during construction	3	3	0	0
13	Avoid chiseling works	3	3	0	0
14	Proper alignment and smooth installation	3	3	0	0
15	Applying effective performance and control system	2	5	3	9
16	Easy access to movement of pre-assembled units around site	3	3	0	0
17	improve capacity of material management system	3	3	0	0
18	Collaboration/ partnering between involved parties	3	3	0	0
19	ensure consistent supply of project material	3	3	0	0
20	proper storage and delivery of fabricated products	3	3	0	0
21	Avoid Machinery accidents	4	4	0	0
	Σ=				9
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	21

ɤ =.995

Table. H. Agreement analysis on improvements on delay (installers and consultant)

No.	Improvements to minimize poor quality aluminum works	Aluminum worker	Consultant	co-a	d2
		Rank	Rank		
1	Protect materials from scratching. Cover profiles with protection tape)	1	1	0	0
2	Perform pre-installation survey for assessment of required openings as per the design specification	1	1	0	0
3	Assign respected skill workforce for various activities	1	1	0	0
4	Organize a qualified team	1	1	0	0
5	Avoid careless erection techniques	1	2	1	1
6	Use proper handling and storage of profiles and accessories	2	5	3	9
7	Perform water tightness test for assuring the quality of work	2	2	0	0
8	Quality assurance and quality management	2	3	1	1
9	as per prefabrication checklist	2	3	1	1
10	as per the mockup	2	3	1	1
11	Educating and training workforce within the organization	2	2	0	0
12	Collaboration/ partnering between involved parties	3	3	0	0
13	Performing post project reviews/ Evaluations for feed back	4	4	0	0
14	Industry wide collaboration on establishing standard training on Aluminum works installation.	5	6	1	1
	Σ=				14
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	14

ɤ =.992

Table. I. Agreement analysis on improvements of delay (consultants and contractors)

No.	Improvements to minimize delay	Contractors Rank	Consultants Rank	co-a	d2
1	Prevent/ Minimize human errors	1	1	0	0
2	Using optimization software for quantifying	1	1	0	0
3	Use CNC machines for fast and precise production	1	1	0	0
4	Engaging 'key parties' at the planning stage	1	1	0	0
5	Training to Aluminum production and installation team	1	1	0	0
6	Organize a qualified team	1	1	0	0
7	Adequate coordination between procurement, production and installation works	1	1	0	0
8	Effective and Integrated work plan for site activities	1	1	0	0
9	Practice of demonstrating the flow of work and deliverables using mockups	1	1	0	0
10	Assign workforces based on their expertise	1	1	0	0
11	Practice of developing suitable production and installation techniques in line with the technology	1	2	1	1
12	Prepare optimum working window-door openings during construction	3	1	-2	4
13	Avoid chiseling works	3	1	-2	4
14	Proper alignment and smooth installation	3	1	-2	4
15	Applying effective performance and control system	5	2	-3	9
16	Easy access to movement of pre-assembled units around site	3	3	0	0
17	improve capacity of material management system	3	3	0	0
18	Collaboration/ partnering between involved parties	3	3	0	0
19	ensure consistent supply of project material	3	3	0	0
20	proper storage and delivery of fabricated products	3	3	0	0
21	Avoid Machinery accidents	4	4	0	0
	Σ=				21
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	21

ɣ =.987

Table. J. Agreement analysis on improvements of quality (installers and contractors)

No.	**Improvements to minimize poor quality aluminum works**	**Aluminum worker**	**Contractor**	**co-a**	**d2**
		Rank	Rank		
1	Protect materials from scratching. Cover profiles with protection tape)	1	1	0	0
2	Perform pre-installation survey for assessment of required openings as per the design specification	1	1	0	0
3	Assign respected skill workforce for various activities	1	1	0	0
4	Organize a qualified team	1	1	0	0
5	Avoid careless erection techniques	1	2	-1	1
6	Use proper handling and storage of profiles and accessories	2	5	-3	9
7	Perform water tightness test for assuring the quality of work	2	2	0	0
8	Quality assurance and quality management	2	2	0	0
9	as per prefabrication checklist	2	2	0	0
10	as per the mockup	2	2	0	0
11	Educating and training workforce within the organization	2	2	0	0
12	Collaboration/ partnering between involved parties	3	3	0	0
13	Performing post project reviews/ Evaluations for feed back	4	4	0	0
14	Industry wide collaboration on establishing standard training on Aluminum works installation.	5	6	-1	1
	pZ				11
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	14

ɣ =.95

Table. K. Agreement analysis on improvements of quality (installers and consultants)

No.	Improvements to minimize poor quality aluminum works	Aluminum worker	Consultant	co-a	d2
		Rank	Rank		
1	Protect materials from scratching. Cover profiles with protection tape)	1	1	0	0
2	Perform pre-installation survey for assessment of required openings as per the design specification	1	1	0	0
3	Assign respected skill workforce for various activities	1	1	0	0
4	Organize a qualified team	1	1	0	0
5	Avoid careless erection techniques	1	2	1	1
6	Use proper handling and storage of profiles and accessories	2	5	3	9
7	Perform water tightness test for assuring the quality of work	2	2	0	0
8	Quality assurance and quality management	2	3	1	1
9	as per prefabrication checklist	2	3	1	1
10	as per the mockup	2	3	1	1
11	Educating and training workforce within the organization	2	2	0	0
12	Collaboration/ partnering between involved parties	3	3	0	0
13	Performing post project reviews/ Evaluations for feed back	4	4	0	0
14	Industry wide collaboration on establishing standard training on Aluminum works installation.	5	6	1	1
	pZ				14
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	14

ɤ =.95

Table. L. Agreement analysis on improvements of quality (consultants and contractors)

No.	Improvements to minimize poor quality aluminum works	Consultant Rank	Contractor Rank	co-a	d2
1	Protect materials from scratching. Cover profiles with protection tape)	1	1	0	0
2	Perform pre-installation survey for assessment of required openings as per the design specification	1	1	0	0
3	Assign respected skill workforce for various activities	1	1	0	0
4	Organize a qualified team	1	1	0	0
5	Avoid careless erection techniques	1	2	1	1
6	Use proper handling and storage of profiles and accessories	2	5	3	9
7	Perform water tightness test for assuring the quality of work	2	2	0	0
8	Quality assurance and quality management	2	2	0	0
9	as per prefabrication checklist	2	2	0	0
10	as per the mockup	2	2	0	0
11	Educating and training workforce within the organization	2	2	0	0
12	Collaboration/ partnering between involved parties	3	3	0	0
13	Performing post project reviews/ Evaluations for feed back	4	4	0	0
14	Industry wide collaboration on establishing standard training on Aluminum works installation.	5	6	1	1
	Σ=				11
	co=contractors rank, a=aluminum workers rank, cu=consultant rank and d= difference of ranks			n=	14

ɤ =.81